TEACHING CLIMATE CHANGE: PRESSURES AND PRACTICE IN THE MIDDLE SCHOOL SCIENCE CLASSROOM

by

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THESIS ABSTRACT

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What are middle school science teachers teaching their students about climate change? And why? This qualitative study examined the experience of middle school science teachers from western Oregon, finding that while participating teachers accept the science of climate change and express concern about it, many teachers are reluctant to make the topic a priority in their classrooms. When they do include the subject, teachers frequently address "both sides." They also report that students have persistent doubts and misconceptions about climate change. What accounts for these trends? I argue that the way teachers address climate change is a result of complex interactions between structural pressures, emotional pressures, and cultural pressures. I conclude that, in order to promote the inclusion of sound climate science instruction in public schools, advocates of climate change education need to address challenges at all these levels: structural, emotional, and cultural.

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CHAPTER I

TEACHING CLIMATE CHANGE: PRESSURES AND PRACTICE

"But we obviously have got to inform our global population about this huge, humongous threat—because it is… you can't do anything about it until you know about it, so I think certainly you can't avoid talking about it" (Isaac, middle school science teacher, rural Oregon).

Introduction

What should students know about climate change? And how should teachers teach it? While scientists have come to a general agreement about the causes and effects of human-induced climate change, educators continue to struggle with this topic, not sure whether and how to convey this scientific information to students. Like the similarly fraught topics of Sex Ed and evolution, climate change presents challenges to both teacher and student, not only because the science itself is complex, but also because the social forces affecting how participants communicate and respond to the science are complex as well. Of course, one of the more significant social factors affecting climate change communication is political controversy; climate change has become an increasingly polarizing issue in the last decade, thanks in part to the concerted efforts of the climate skeptic movement (Greenpeace, 2013; Oreskes & Conway, 2010). Political controversy affects climate change at the state level, where policymakers dispute the content of educational standards (Bidwell, 2014) as well as the local level, where teachers, administrators, parents, and students must negotiate whether and how to include this topic in schools (Reardon, 2011). Even in communities where climate change is not

particularly politically divisive, other social and emotional factors—such as students' feelings of hopelessness, or a teacher's fear of instigating conflict—may further complicate climate change in the classroom.

This study examines the issue of climate change education from the perspective of teachers, in order to understand how certain educators address climate change in the classroom and how structural, emotional, and sociocultural factors may affect their teaching practice. Or, in other words: When it comes to climate science, what are teachers teaching their students—and why?

Why Is Climate Education Important?

Despite the inherent difficulties of teaching climate change, climate education advocates, like Mark McCaffrey and Joshua Rosenau at the National Center for Science Education, insist that students should learn the scientific basis for climate change, because climate literacy "provides society with the tools and shared basis for understanding the science and solutions before us" (2012). One oft-cited resource for climate education, called "Climate Literacy: Essential Principles of Climate Science," confirms this assertion, adding that "Climate science literacy is a part of science literacy" in general (U.S Global Change Research Program, 2009, pg. 3). If the primary goal of science education is to help students understand how the physical world works, then students should learn about the carbon cycle, the function of greenhouse gases in the atmosphere, and the effects of climate on humans and other species for the same reason that they should understand plate tectonics, covalent bonding, and Newton's laws of physics—these phenomena are central to understanding the material world around us.

However, the goals of climate change education are more than informative; as most climate education advocates will readily admit, teaching climate change is different from teaching the quadratic equation or *King Lear* because there is an explicitly prescriptive element; the goal is not merely to produce knowledge, but to inspire changes in attitude and behavior as well, preparing young people to become tomorrow's (or perhaps today's) climate-conscious citizens, leaders, and problem solvers.

This normative aspect of climate change education is invoked in popular media, teaching resources, and academic literature. For example, a 2014 press release describing a new White House Climate Education and Literacy Initiative asserted, "Continued progress into the future will depend on ensuring a climate-smart citizenry and a next-generation American workforce… who understand the urgent climate-change challenge and are equipped with the knowledge, skills, and training to seek and implement solutions" (White House, 2014). The previously cited "Climate Literacy: Essential Principals" stresses that education for climate literacy is essential for producing citizens that "understand the climate system and know how to apply that knowledge in their careers and in their engagement as active members of their communities" (U.S Global Change Research Program, 2009, pg. 3). In scholarly journals, too, authors frequently invoke the normative, as well as informative, goals of climate change education. In a 2014 review of 92 peer-reviewed studies on climate change education, Victoria Wibeck observes, "Since climate change is expected to have severe consequences for many citizens around the globe, considerable money and effort have been invested in educating the public of the causes and effects of climate change and of how laypeople should behave to mitigate and adapt to a changing climate" (Wibeck, 2014, p. 387). Another

scholar notes, “Preparation for the responsibilities of citizenship in a global society, as well as development of individual sustainable lifestyles, should dictate that global climate change appear in formal education” (Fortner, 2000, p. 19).

While many have argued for the importance of science literacy in general—and climate literacy in particular—for developing a concerned, climate-active citizenry, others have questioned whether science education can actually fulfill this role. Some sociological studies have found that scientific literacy is actually poorly correlated with belief in anthropogenic climate change (see for example, Kahan, 2013). What’s more, understanding the science doesn’t necessarily lead a person to feel more concern about climate change; nor does knowledge automatically generate the kind of collective action necessary to mitigate this global phenomenon (Norgaard, 2011).

Where some educators might like to imagine a simple path connecting knowledge about climate change to belief, concern and a set of certain “pro-climate” behaviors, social scientists, meanwhile, see not one path, but a network of paths, constantly branching, crisscrossing, and leading to innumerable destinations. From the perspective of environmental sociology, it would be naïve to assume that scientific literacy, on its own, will spur a widespread, appropriate, and timely response to climate change.

At the same time, however, it would be cynical to suggest that science education, at its best, plays *no* role in developing the kind of “climate-smart citizenry” that, according to the White House Climate Education and Literacy Initiative, might mitigate the problem of climate change. While climate literacy may not be a silver bullet, it is still necessary. This thesis is based on the assumption that science education is one essential tool that, when implemented well, can promote both knowledge and action-oriented

concern about climate change. This begs the question though: How *are* educators incorporating climate change into their science education toolbox? And, to what effect?

Climate Education in the Context of Western Oregon

Western Oregon is a unique and timely place to study climate change education, both because of its political diversity and because of the way Oregon, at a state level, has promoted science education in general and environmental literacy in particular.

Compared to other states, Oregon's educational standards are relatively progressive in their treatment of climate change; this is an important fact to recognize when considering whether and why teachers from this state include climate science in their curricula. In 2014, Oregon adopted the Next Generation Science Standards (NGSS), joining a group of now twelve states in establishing a new set of benchmarks for student achievement in science (ODE, 2014). These new standards have received attention in part because of their unapologetic treatment of socially controversial science topics, including climate change and evolution (Bidwell, 2014). The older, Oregon State Standards (which set benchmarks for the state from 2006 to 2014) included learning goals related to atmospheric processes, but did not explicitly reference "climate change," "global warming" or human impacts on the atmosphere; as a result, they set no clear expectation regarding what, if anything, students should understand about global climate change. The NGSS, on the other hand, clearly state that middle school students should be able to "Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century." In case there remains any doubt about what those "factors" are, the standards further specify: "Emphasis is on the major role that human

activities play in causing the rise in global temperatures" (MS-ESS3-5). At the time that I collected data for this study (summer and fall of 2014), the NGSS had only recently been passed, and was not in full implementation throughout the state. For the purposes of this study, the passage of the NGSS is significant because it indicates that the Oregon educational system, at a state level at least, supports the inclusion of sound climate science in classrooms. At a time when 40 percent of Americans express either outright skepticism or ambivalence regarding the fact of climate change and/or its anthropogenic origin (Leiserowitz, 2012), it is significant that Oregon's state-sanctioned science standards would express neither skepticism nor ambivalence on the subject.

In addition to the NGSS, which are specific to science, Oregon also passed the Oregon Environmental Literacy Plan (OELP) in 2010, a supplementary set of learning goals "designed to ensure that every student in Oregon becomes a lifelong steward of their environment and community" (p. 3). The various learning strands listed in the OELP are meant to "Prepare students to understand and address the major environmental challenges facing this state and country, including the relationship of the environment to national security, energy sources, *climate change*, health risks, and natural disasters (p. 3, emphasis mine). The OELP is a set of "strands," not "standards;" it is separate from state standards in science, math, or literacy, and is designed to support and supplement learning goals in each of these areas.

In the context of climate education, the NGSS and the OELP are significant because they indicate that, at an administrative level at least, the state of Oregon is fairly supportive of teaching sound climate science. This becomes especially apparent when you compare Oregon to other states, where climate education is much more contentious.

Lawmakers in Wyoming, for example, blocked the passage of the NGSS because of its emphasis on anthropogenic climate change; as state board of education chairman Ron Micheli, explained, "I don't accept, personally, that [climate change] is a fact" and the standards are “very prejudiced in my opinion against fossil-fuel development” (Todd, 2014).

Despite having a unified set of science standards at the state level, Oregon remains a diverse place at the community-level. From the relatively affluent, metropolitan, and politically liberal cities of Multnomah County, to more rural, resource-driven, and politically conservative districts like Curry County, western Oregon may harbor diverse attitudes about climate change and its inclusion in public school curricula. Thus, in this research I was careful to include the perspectives of teachers from the suburbs of Portland as well as the logging towns of Curry County, and the agricultural hamlets and university towns in between (see Methods, below). As I will show, teachers from these diverse communities actually shared significant challenges and experiences in regard to teaching climate change.

Research Questions

The following questions have guided my research:

- *Practice:* How, if at all, are middle school science teachers in western Oregon teaching the subject of climate change? What successes or challenges do they report?

- *Pressures:* What factors, both tangible and intangible, pressure teachers to address climate change in this way? How might these pressures explain the successes and challenges teachers describe?

Comparing the science classroom to a theater, the first question essentially asks: *What's happening on stage?* What story is being told, and how? The second question asks: *What's going on behind the scenes?* And, how does this behind-the-scenes activity shape the on-stage performance? Figure 1 illustrates how *pressures* (behind-the-scenes factors) inform *practice* (what happens on stage). This diagram may serve as a road map for the rest of this narrative, previewing both the topics I will cover and how those topics are related.

With regards to the first question, I found that teachers use a variety of strategies to teach climate change, and with various results. However, several trends emerged. In Chapter II, I address four main trends that characterize climate change in the classroom. These include: the fact that teachers acknowledge and express concern about climate change; teachers report difficulty in making climate change "fit" into their curricula; teachers often address "both sides;" and students persistently maintain doubts and misconceptions about climate science. (See lower box in Figure 1).

With regards to the second question, I argue that not one factor, but *many* factors influence teachers' treatment of climate change and that these factors fall into three main categories: direct barriers, emotional pressures, and norms of the culture of science teaching (See upper three boxes in Figure 1). In Chapter III, I will address this first category, illustrating how factors like educational standards, curricular resources, and

teachers' own knowledge of climate change may directly support or frustrate climate change education.

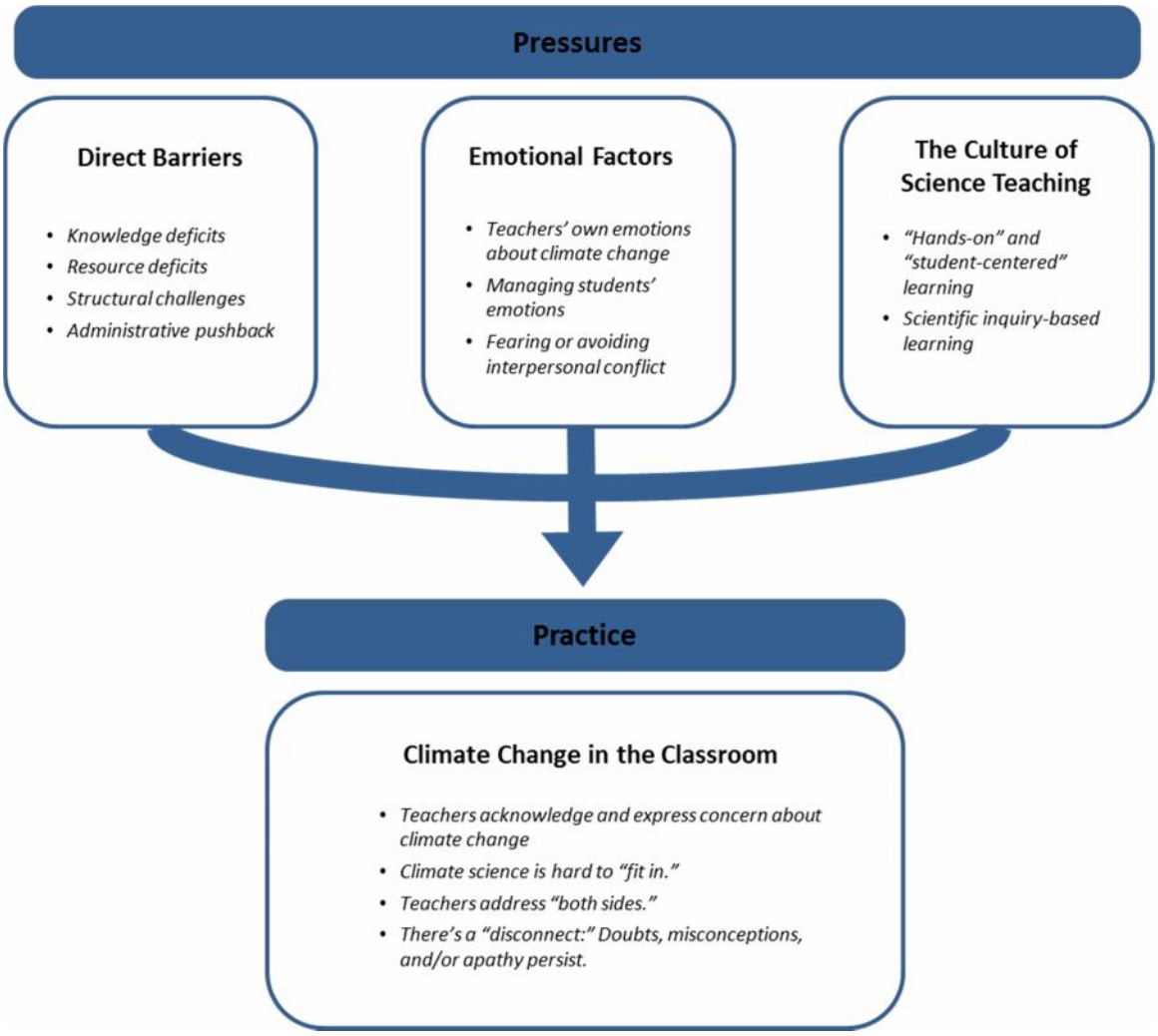

Figure 1. Logic Model

In Chapter IV, I turn from these relatively tangible barriers to the more intangible realm of emotions; here I will discuss how emotional pressures, including feelings of anxiety, sadness, personal responsibility, or fear of controversy, may affect the way teachers and students deal with the subject of climate change.

Finally, in Chapter V, I discuss how teachers' beliefs and practices regarding climate change education are informed by a broader set of norms and narratives endemic to their profession—what I'm calling the "Culture of Science Teaching." Here I identify certain assumptions that teachers and their peers hold about what constitutes *good* science teaching. I then examine how these assumptions may inform the way teachers address or avoid climate change in the classroom. For example, teachers repeatedly defended the importance of "hands-on" learning, a best practice that is easily applied to topics like stream ecology (where students can see, touch, and manipulate water in an actual stream), but more difficult to apply to climate change, because students can't rely on their own observations or experiments to understand the science.

While it's tempting to reduce the pedagogical problems of climate change to one or two distinct challenges—Teachers are scientifically illiterate! Or, climate skeptics are to blame!—I argue that the way teachers address climate change (and the way that students, in turn, respond) is a result of complex interactions between structural pressures, emotional pressures, and cultural pressures. Or, to return to the theater metaphor, a stage performance isn't shaped solely by the actors themselves, or even by the script; it's shaped by the available props, the behind-the-scenes relationships between cast and crew, the actors' own emotional states, norms of theater culture, and a thousand other factors. By focusing on so many different pressures—rather than examining one specific variable, like teachers' knowledge of climate science—I sacrifice some depth for breadth. In doing so, however, I hope to illuminate the complexity of this issue. The implication for advocates of sound climate change education (and it should be noted that I consider myself one of them) is that, in order to promote the inclusion of sound climate

science instruction in public schools, we need to address challenges at all these levels: structural, emotional, and cultural.

Methods

This study builds on the interdisciplinary field of climate education research and is informed by science education studies, environmental education studies, and sociology. In an attempt to address the research questions outlined above (that is, the *how* and *why* of climate change in the classroom), I took a qualitative approach, combining formal and informal interviews with participant observation.

Participant Recruitment

In order to understand how and why teachers address the subject of climate change, I went directly to the source—recruiting 15 middle school science teachers from western Oregon.

Teacher participants were initially recruited via emails distributed to 56 different middle schools in 25 school districts in western Oregon. This initial recruitment process yielded six participants from five different school districts. Those initial recruits, in turn, connected me with additional teachers. These snowballing referrals, along with the referrals of other friends and colleagues, generated a sample of 15 secondary science teachers from western Oregon.

During the recruitment process, I intentionally avoided mentioning my interest in climate change; instead I invited teachers to participate in a study about "teaching environmental science topics and the Next Generation Science Standards." This approach

was strategic in two ways. First, it mitigated somewhat the threat of self-selection bias: I wanted to recruit teachers with a wide variety of interests and affiliations, not just those who felt particularly passionate or informed about climate change. Secondly, in order to answer the question of practice, I had to understand not only how teachers approach climate change, but how they might approach climate change *differently* from other topics included in middle school science. By beginning each interview with a conversation about science teaching in general—i.e. how do you decide what topics to teach? What activities or teaching strategies do you use? What challenges do you face?—I could get a sense of what topics the teacher prioritizes in the classroom, and whether climate change was one of those topics. Then, after prompting the participant to discuss climate change specifically (usually after about 30 minutes of more general discussion), I noted whether and how the respondent's treatment of climate change differed from other science topics, like plate tectonics or plant adaptation.

Admittedly, this sample is not random, nor is it representative of all public middle school teachers in western Oregon. Rather, it represents a select group of educators from a variety of communities both urban and rural, liberal and conservative. Teachers that I spoke to came from university towns, farm towns, and busy suburbs. Some had taught for thirty years; others had just finished their first year in the classroom. All of them where white. Most of them (12 of 15) were women. All the participants expressed passion for education, a love of science, and concerns about the challenges they faced as teachers. Table 1 lists participating teachers (whose names have been changed), along with the number of years they have been teaching and the kind of community they teach in.

Pseudonym	Location	# of years teaching
Andrea	Large, metropolitan suburb	1 year
Hailey	Medium-sized suburb	1 year
Dan	Medium-sized rural town	5-10 years
Elizabeth	Small, rural town	5-10 years
Faith	Small, rural town	5-10 years
Gabby	Medium-sized university town	5-10 years
Lauren	Large, metropolitan suburb	5-10 years
Nicole	Medium-sized university town	5-10 years
Olivia	Medium-sized university town	5-10 years
Paul	Medium-sized suburb	5-10 years
Carly	Small, rural town	10-20 years
Kathy	Large, metropolitan suburb	10-20 years
Megan	Small, rural town	10-20 years
Brenda	Medium-sized university town	20-30 years
Isaac	Medium-sized rural town	30-40 years

Table 1. List of Participating Teachers

Formal Interviews

Because my research focused not on quantifiably measurable phenomena like student test scores, but on qualitative phenomena like emotions, social pressures, and beliefs about the nature of science, I chose to adopt a qualitative approach to interviewing. As qualitative sociologist Robert Weiss puts it, we can learn, “through interviewing, about people’s interior experiences. We can learn how events affected their thoughts and feelings. We can learn the meanings to them of their relationships, their

families, their work, and their selves" (1994, p. 1). Weiss identifies the heart of what I hoped to examine through qualitative interviewing: the relationship between experience, thoughts, feelings, relationships, and work, all in the context of teaching climate change.

Thus, the bulk of the data informing this study came from fifteen formal, qualitative interviews with the middle school science teachers listed above. I call these interviews "formal" in order to distinguish them from shorter, "informal" interviews completed during participant observation (addressed below). However, these conversations were anything but stiff or prescriptive. Though I began each interview with a few predetermined questions (see Appendix), participant responses also generated new questions and drove the conversation in unexpected directions; as a qualitative researcher, I happily indulged these diversions. Interviews lasted between 45 and 90 minutes, were audio recorded, and later transcribed by the researcher.

Participant Observation and Informal Interviews

In order to provide some context for teachers' reports about science teaching, I supplemented data from formal interviews with field observations at a two-day science teaching conference. This gathering, here fictionally called the "State Science Teachers Conference," drew together hundreds of formal and informal science educators from all over the state of Oregon. As an educator myself, I comfortably joined other participants in a variety of sessions focused on science pedagogy. Several of these sessions explicitly addressed climate change; others did not. At all of the sessions, I participated in discussion and hands-on activities while simultaneously jotting notes, which I developed into full field notes at the end of each day.

Through participant observation, I was able to observe teachers in the context of their professional community, engaging in practice and talking to *each other* (rather than an outside researcher) about science teaching.

Between sessions and during breaks, I approached individual teachers and groups of teachers, introduced myself as a researcher, and engaged them in conversations about science teaching in general and climate change specifically; I refer to these conversations as "informal interviews." This on-the-spot recruitment gave me access to more teachers than I would have otherwise had access to. Like with participant observation, I took notes during these individual and group interviews (rather than audio-recording) and then filled in these notes with more detail immediately following the conversation.

Data Analysis

As the sole interviewer, transcriber, and coder for this project, I developed an intimate relationship with my data. In order to answer my relatively broad and open-ended research questions, I used a strategy of data analysis informed by grounded theory. According to ethnographer Kathy Charmaz, "grounded theory methods consist of systematic, yet flexible guidelines for collecting and analyzing qualitative data to construct theories 'grounded' in the data themselves" (2006, p. 2). Grounded theory emphasizes inductive rather than deductive analysis, meaning, rather than pre-determining relevant themes and assigning data to fit those themes, the researcher tries to approach each piece of data without preconceived notions, assigning thematic codes as they emerge. This emergent, open-ended method was appropriate for this study, as I was not testing a specific hypothesis (i.e. "Resource deficits lead to lower rates of climate

change instruction," or "political conservatism is correlated with negative views of environmental education"), but rather exploring a broader network of connections between teaching practice and diverse structural, emotional, and cultural factors.

With this goal in mind, after transcription, I used Charmaz's method of first using line-by-line coding to sieve through a random sampling of four transcripts; this process generated hundreds of specific, descriptive codes, such as "expressing fear," "using textbooks," or "getting pushback from parents." I then analyzed these initial codes, combining and distilling them into a smaller set of analytical, or "focused" codes. These focused codes identified recurrent themes, like "negative emotions," "pedagogical practices," and "pushback/conflict." I then went back to my transcripts and applied these new, focused codes to each interview and field note set, occasionally adding more focused codes to my list, as necessary. This emergent process helped reveal unanticipated ideas, which I have combined with ideas taken from existing literature to build the argument I will present here.

Study Limitations

As with all research studies, this one has its strengths and limitations. Due to the short time frame of this project, the sample size is modest, based primarily on data from just fifteen individuals. That said, even within this modestly-sized sample, I was able to identify recurrent themes, both in relation to the pressures teachers experience and the educational practices they employ in response to these pressures.

Because this study is based on a small sample size and utilized selective (i.e. not random) recruitment methods, it may not reflect the *general* views and experiences of

middle school science teachers in western Oregon. Even though I took pains to limit recruitment bias by withholding my interest in climate change during recruitment and by utilizing broad, email recruitment rather than relying solely on snowball referrals, it is still likely that the teachers who agreed to participate in this study differ in certain (though unknown) ways from the collective pool of middle school science teachers in western Oregon.

Due to these and other limitations, this study does not claim to be random or representative. Through this study, I hoped to better understand how various pressures shape teacher practice in the context of climate change. While I won't argue that *all* teachers in western Oregon experience the same pressures my study participants report experiencing (or that all teachers inevitably respond to those pressures in the same way), I would argue that anyone concerned with promoting climate literacy should be interested in the complex factors that may facilitate or frustrate meaningful climate science teaching in the classroom. I believe that, despite the aforementioned limitations of sample size and representativeness, this study *does* effectively assess these factors, and does so in a way that helps answer the original research questions: How do teachers teach climate change? And why?

About the Researcher

This discussion of methods would not be complete without addressing my own background, biases, and interests in the subject of climate change education.

I first encountered some of the challenges of teaching climate change through my own experiences as an educator. For several years, I worked as an educator at a science

museum. While in this position, I was part of a small team that developed and taught a one-hour class about climate change for grades 4-8. At the time, it seemed like the primary challenge was one of sheer information-overload: How do you consolidate a mountain of scientific information into a 60-minute period? Upon implementing the lesson, however, my colleagues and I discovered myriad other challenges, including students who were bored or disengaged, complaints from parents that the material was too depressing, and our own discomfort, as educators, about delivering politically controversial content. Later, as a teaching assistant for a college-level environmental studies course, I encountered additional challenges. I found for example that most of the first-year students I taught were surprisingly ignorant of basic climate science. Many of them harbored misconceptions—including the classic one, confusing global warming with ozone thinning—and these misconceptions often persisted, even after my attempts at re-instruction. I also found that students were much more comfortable talking about environmental problems when they were able to cite simple, individualized solutions to those problems, like riding a bike, buying organic produce, and using reusable grocery bags. I realized that students' misconceptions about climate science and about viable solutions to climate change were informed not by science knowledge per se, but by their own experiences and emotions, not to mention larger cultural narratives about climate change.

What I learned through these and other experiences is that, while any subject can be difficult to teach, climate change is particularly difficult—and, that part of the difficulty came from the social, emotional, and cultural factors affecting both my own and my students' response to the material. Teaching climate change remains difficult

even though I have a solid understanding of climate science, a strong conviction about the reality of climate change, a personal concern about the issue, and the full endorsement of my academic institution to teach the subject.

My own experiences led me to wonder: Are other teachers experiencing these or other challenges? What explains these challenges? How are teachers dealing with them?

One final word: This report is not meant to be a scathing critique of science teachers nor a unilateral declaration of best practices in climate change education. Rather, this work is inspired by the challenges I have experienced (and observed others experiencing) in the context of teaching climate change; it is built on a limited, though thoughtfully analyzed selection of data; and, it is presented with the hope that others—particularly other educators—would read it and reflect on the meaning of climate change education and its place in public school classrooms.

CHAPTER II

CLIMATE CHANGE IN THE CLASSROOM: FOUR TRENDS IN PRACTICE

Teaching is not an easy job. Ask any middle school teacher what makes her profession difficult and she will likely list off a litany of grievances: the classes are too big, the days are too short; the work load is too high, the compensation is too low; standardized tests are too onerous and resources too few. On top of these structural challenges are the social and emotional challenges of dealing with students, administrators, parents, and other teachers, all the while managing one's own psychological well-being. It's in this context that teachers are faced with another difficult task: teaching climate change.

Much of the literature on climate change education serves to document its failures—from students' faulty mental models of the greenhouse effect (Shepardson, Choi, Niyogi, & Charusombat, 2009), to the tendency of teachers to teach "both sides" of climate change (Wise, 2010). Based on my familiarity with this literature (not to mention my own experience teaching climate change), I entered into this research with the assumption that climate change, more than other science topics, is challenging for both teachers and students.

At the same time, I was unsure of what sorts of challenges, exactly, these particular teachers faced in the context of climate change. Perhaps teachers felt inadequately educated on the topic or couldn't find resources to help educate their students. Maybe they faced pushback from climate skeptics in their community; perhaps they were climate skeptics themselves. Or, perhaps my interviews with teachers would

reveal that climate change *isn't* a particularly difficult topic—at least, no more difficult than the water cycle or the periodic table.

In fact, teachers did report experiencing challenges unique to the topic of climate change, but not always in ways that I expected. Naturally, every teacher's experience of teaching climate change was different; each experienced unique assets and limitations, leading to unique successes and setbacks. However, out of this scatterplot of individualized experience emerged several trends, which I will address here. These include:

- Teachers acknowledge and express concern about human-caused climate change.
- Teachers report that climate change is hard to "fit in."
- Teachers present climate change as an issue with "two sides."
- Despite teachers' best efforts, students continue to express doubts, misconceptions and/or apathy about climate change ("there's this disconnect.")

The first trend is actually good news, not a challenge per se. The following three trends presented more of a problem for teachers and students, and so I will spend more time discussing them.

In this chapter, I will attempt to answer the question of *practice*—that is, what teachers are actually doing in the classroom, and how students, in turn, are responding—by describing each of these four broad patterns and commenting on their significance.

Teachers Acknowledge and Care about Anthropogenic Climate Change

While preparing for this project, I came across an article on the New York Times' Learning Blog, a publication aimed specifically at educators. The post invited current teachers to weigh in on the newly minted Next Generation Science Standards (Contaro & Shulten, 2013). While the comments that poured in may not constitute a rigorous sociological study, they certainly revealed a diversity of opinions on the issue. One high school science teacher praised the NGSS' focus on anthropogenic climate change, explaining that "climate science [is] an example of one of the great scientific pursuits of the day." Countered another educator, "As a high school science teacher with over 20 years [sic] experience, I would think that literacy, numeracy and behaviour would take priority over 'climate change' – especially when 'climate change' while compelling has not yet been proven scientifically."

This educator's skeptical stance shouldn't come as a shock, given that a sizeable percentage of Americans continue to doubt the scientific consensus about climate change. An April 2013 study by the Yale Project on Climate Change Communication reported that 13% of Americans believe that climate change is not occurring. What's more, 33% of Americans believe that, if it is occurring, the cause is primarily "natural," not anthropogenic. The amount of concern Americans express about climate change is also mediocre; only half of Americans indicate they are "somewhat worried" or "very worried" about climate change (Leiserowitz et al., 2013). Based on this data—and my own memorable, personal experiences encountering climate skeptics—I entered into this research prepared to meet a few teachers who rejected the science behind anthropogenic climate change or who brushed it off as a non-threat.

In reality, I met none.

Admittedly, this study is small, and takes place in a relatively liberal region of the United States. However, it is significant that all the teachers I interviewed expressed concern about climate change, and all but one confirmed that humans are the primary cause. Gabby, a seventh-grade teacher from a university town, asserted that climate change is "definitely one of the most important things for our kids to learn, because in the next fifty years if it keeps going it's going to change a lot. Not so much for us in Oregon, maybe, but other places are going to [see] big differences in their climate and their culture and everything." Several teachers referred to local evidence of climate change, while simultaneously expressing their concern about those impacts. Elizabeth noted that "climate change will drastically impact our water in a very, potentially scary way" and Olivia voiced her fear about wildfires in southern and eastern Oregon, noting, "If we don't change something soon, it will spin out of control."

Far from being ignorant or ambivalent about the subject, these teachers demonstrated their knowledge of and concern about the very real effects of climate change. Similarly, teachers consistently expressed their wish that others, students included, would share this same knowledge and concern. Faith noted, "more than half of my students don't believe in climate change. And so my role is to convince them that, you know, it exists; there is data." Lauren, a self-described science nerd and environmentalist, felt particularly frustrated with those who hold skeptical views: "I… don't understand how other people don't understand about it—that it *is* a problem… how people can just be like, 'Yeah, it doesn't exist.'"

Throughout our conversations, teachers repeatedly confirmed, in both direct and indirect ways, their respective beliefs in the reality and severity of climate change. And, all but one clearly connected the phenomenon of climate change to human activities. Notably, there was no discernable relationship between a teacher's geographical location (and by extension, the political climate in his or her community) and the likelihood of that teacher expressing concern or skepticism about climate change. The only teacher to express any remotely skeptical perspectives on climate change was Paul, a seventh-year teacher stationed in a medium-sized suburb in the Willamette Valley. Paul explained, "Well I don't think anybody debates *if* it's happening. I don't even think that's remotely a debate. I think the debate's more about what the causes are, and if it can be reversed." Paul was careful to clarify that he didn't consider himself a climate skeptic; rather, he expressed some uncertainty about whether humans were solely to blame, or if natural phenomena may also play a role in current warming. While Paul's stance on climate change is somewhat troubling, it's significant to note that, out of the fifteen teachers I interviewed, he was the only one to express such a stance.

This study's findings are supported by other studies, which indicate relatively high levels of climate change acceptance among educators. A survey by the National Earth Science Teachers Association, for example, found that 89% of responding teachers "indicated that they believe global warming is happening" (Johnson & Holzer, 2011) compared to roughly two-thirds of American adults in general. For those who worry that climate education may be thwarted by teachers who disbelieve climate science or dismiss the significance of current warming, this and other studies should offer some relief; it seems that most teachers both believe in and care about climate change.

Climate Change Is Hard to "Fit In"

The good news, I have argued, is that teachers in this study seem convinced and concerned about climate change, and want others to feel the same. Also, most teachers are taking steps to educate their students about this topic; with just two exceptions, all the teachers I interviewed reported that they have addressed climate change at some point in their classes. However, not all teachers fit the topic into their curricula in the same way. As illustrated in Table 2, below, some teachers taught comprehensive, focused lessons on climate change, while others, if they taught it at all, incorporated it in a more indirect or passing way.

How do teachers fit climate change into their curricula?

Teach multi-day unit focused on climate change	Teach climate change indirectly, in context of other topics	Teach brief lesson on climate change (one day or less)	Taught climate change in the past, but no longer do so	Don't teach climate change at all
Elizabeth Olivia Lauren Carly Nicole	Brenda Faith Megan	Isaac Paul	Kathy Daniel Gabby	Hailey Andrea

Table 2. "Fitting In" Climate Change

A common refrain among teachers, when explaining why they minimize the topic of climate change or why they do not currently teach it, was that climate change is hard to "fit in." Paul confesses, "We talk about it, but very briefly, only because I don't know where it fits, to be honest." His lesson on climate change consists of a single activity,

lasting less than one class period, in which he leads a discussion about the evidence for and against climate change. Dan echoed Paul's sentiment that climate change, "unfortunately, doesn't really fit in my program very well." He further explained that "we talk in very broad, general terms about human impacts… greenhouse gases and the amount of pollution, and what we do as individuals, how that contributes to the global warming." However, he does not teach a dedicated unit on climate change. In past years, Dan showed students *An Inconvenient Truth*, but he reports, "it's been a while since I even taught that unit at all." Gabby and Kathy, similarly, admitted that while they have taught climate change in years past, they haven't taught it recently.

Three teachers reported that they address the topic indirectly, by incorporating aspects of climate science into other lessons. Megan, for example, addresses climate change during her units on energy and earth history; in these units, "we talk a lot more about human impact on the earth," she explains, "instead of having a section on climate change." Similarly, rather than emphasizing the mechanics or consequences of modern, anthropogenic climate change, Faith addresses the subject in the context of geologic and human history. When I asked her how she teaches her students about climate change—"do you use discussions, do you use videos, do you have lectures, do you do readings?"—Faith explained, "I spend a lot of time actually going through how the world was in the past." According to Faith, the goal is:

> To be able to give students a foundation in the idea that the world is constantly changing… So we talk about, 'What was America like when the Vikings came here? What about the medieval warm? How did that help and hurt people in the past? How did our ancestors deal with this? Hey look where the continents used to be.' Trying to get into plate tectonics. And, I'm pulling up a lot of that high-interest stuff that's like, *really* old. I studied animals that lived in the ocean during dinosaur time. So it's like—sea monsters! Awesome! And then you go into [how

> climate change affected the dinosaurs]. You know, the world is still changing.

Faith's approach to teaching climate change, like Megan's, is somewhat indirect. Rather than explicitly teaching students about the carbon cycle, fossil fuels, or current warming trends, Faith prefers to weave some of this content into lessons on loosely related topics, like paleozoology, plate tectonics, and medieval history. Based on Faith's report, it's unclear whether she spends much time at all on the causes or consequences of modern, anthropogenic climate change. Brenda, too, reported that she tries to incorporate climate change in "all of our units… definitely in the water cycle, definitely in the weather cycle, definitely in the salmon." By her own admission though, Brenda's strategy of "natural inclusion" (her words), while broad, is sometimes lacking in depth. While she has used a variety of instructional modes to present information about climate change (including videos, discussions, and readings) she reports that when it comes to in-depth lessons, "specifically tying it to climate change, I haven't."

In citing these examples from Brenda, Faith, and Megan, my intent is not to be critical of an interdisciplinary or integrated approach to teaching climate science. Rather, it is to suggest that teachers' tendency to weave climate science into other subjects (rather than teaching it directly, or devoting a whole unit to the subject) suggests, again, that climate change can be difficult to "fit in."

Five teachers did "fit" climate change into their curricula in a more substantial way, but acknowledged the difficulty of doing so. Lauren has a full curriculum that includes forces, matter, the periodic table, the atomic model, and plate tectonics. She reported that "this past year…" for the first time in her six years of teaching, "I was [also] able to get to weather and climate. That was very exciting." Lauren suggests that climate

change, while important, could only be squeezed in after getting through a long list of other topics. Carly, another teacher who taught several lessons dedicated to climate change, notes that the topic is undesirable among her teaching peers: "I'll tell you, I was the first one voted to teach it! And the only one who's ever taught it at this school." Like Lauren, Carly made climate change "fit," but in doing so, set herself apart from her peers, who were reluctant to do the same. Nicole reported spending a substantial amount of time on climate change: "I always talk about climate change," she reported, "—at least once a week." However, she admits that the topic is not a natural fit in her curriculum. When it comes to teaching climate change, Nicole asserts, "I *make* it happen."

The experiences of Lauren, Carly, and Nicole indicate that teachers *can* fit climate change into their curricula. However, the challenges they experience also beg the question: *Why is it so difficult?* Why, when time is short, would Lauren tend to cut out weather and climate, but keep plate tectonics? Why were Carly's colleagues eager to cut climate change out of their own curricula, leaving Carly as the sole communicator of this important topic? Why does Nicole feel that to teach climate change, she has to "*make* it happen?"

At the heart of the issue is what teachers really mean when they say or suggest that climate change "doesn't fit." My conversation with Kathy revealed some of the deeper meaning of this claim. Initially, when explaining why she no longer teaches climate change, Kathy explained, "Well it doesn't really fit into life science." Immediately though, she reconsidered, saying, "Well it sort of does. It's kind of like, it would fit into the natural resources unit… Fossil fuels and…" Here Kathy trailed off and moved to a different topic. We returned to this point later on in the interview, though,

when Kathy mentioned how people aren't doing enough to combat climate change. "It's really important," Kathy said. "I think it is. But yet, if we're not doing anything about it, we probably don't think it's very important. You know?" At this point, I reminded Kathy that she herself doesn't currently teach climate change, and suggested, somewhat apologetically, "This might seem kind of pointed, but would the same logic apply to teaching?"—as in, if you're not *teaching* climate change, perhaps you don't think it's very important. Kathy paused, and then responded, "Yeah! I think I *should* be teaching it!"

My conversation with Kathy suggests that the claim, "Climate change doesn't fit" is more complicated than it seems. Implicit in this claim is the assumption that *other* topics are a *better* fit, and that teachers, in determining what to include or exclude in their curricula, are communicating what they think is essential material for the middle school science classroom. As Kathy herself admitted, "if we're not doing anything about it, we probably don't think it's very important." If teachers aren't making climate change fit, but *are* making stream ecology fit, that would suggest that teachers think stream ecology is more important than climate change—or that stream ecology is preferable in some other way (perhaps easier for kids to understand, less controversial, etc.). So again, what is it about climate change, as a topic, that makes it hard to fit in and easy to cut out?

Another question that I asked nearly all of my interviewees early in our conversation (i.e. before I revealed my own interest in climate change) was, "What environmental science topics do you think are most important for middle schoolers to learn about?" Most teachers responded first by broadly defining environmental science; for example Dan said the most important thing was for students to understand

"stewardship and restoration … human impacts on the environment and what efforts we can do." Kathy responded, "I think getting kids outside, giving them an appreciation of how everything is all connected together." When I pressed teachers to be more specific—what are some of the content areas you cover, or activities you do with students that relate to environmental science as you have defined it?—teachers listed a range of topics they focus on, from recycling to stream restoration, storm water management to school gardens. Out of fifteen teachers, only two voluntarily suggested, before I did, that climate change was one of the more important environmental science topics for students to learn about. (These two teachers were Gabby and Isaac). This indicates to me that, while teachers may verbally affirm the importance of climate science (particularly *after* they are prompted to do so), this topic is not most teachers' highest priority.

Thus, I began to see those four words, "Climate change doesn't fit," as another way of saying, "I don't prioritize teaching climate change." This assessment, while seemingly harsh, isn't meant to condemn teachers for their pedagogical decisions. Rather, it is meant to raise another important question: *Why* are teachers deprioritizing climate change in the classroom, or reporting that incorporating climate change, while possible, is a challenge? Is it that they lack curricular resources? Or is it the fact that climate change, as a topic, is too depressing? What factors might lead teachers to prioritize other science topics at the expense of climate change? I will return to this question throughout the rest of this paper, as I describe how direct barriers, emotional pressures, and cultural narratives may all play a role in teachers' de-prioritization of climate change.

Teachers Present Climate Change as an Issue with "Two Sides"

For the vast majority of scientists, there is only "one side" to the story about climate change: Human activities, primarily the burning of fossil fuels, are increasing the concentration of greenhouse gases in the atmosphere, causing an unprecedented rate of atmospheric warming; this phenomenon has a significant and largely detrimental effect on geophysical systems, ecosystems, and human society. The 2013 Intergovernmental Panel on Climate Change (IPCC) report confidently asserts, "It is *extremely likely* that human influence has been the dominant cause of the observed warming" (emphasis mine). Here, "extremely likely" is not a qualitative measure but a quantitative one, corresponding to a 95-100% probability of accuracy (IPCC, 2013). Corroborating the IPCC report is the oft-cited study alleging that, in a survey of peer-reviewed scientific papers taking any stance on climate change, "97.1% endorsed the consensus position that humans are causing global warming" (Cook, et al. 2013).

That scientific consensus, however, doesn't keep climate change from being a controversial issue in the public realm, where multiple "sides" of the climate change story persist: On one side, climate change is happening, engineered by humans, and cause for alarm; on the other side, climate change (if it's even happening) is a product of natural processes and not worthy of alarm. Indeed, a small but well-organized movement of climate skeptics has kept this "other side" of the climate change story alive, leading Americans to believe that climate change remains a matter of debate, rather than scientific certainty (Greenpeace, 2013; Oreskes & Conway, 2010). In fact, one of the major players in the climate skeptic movement, the Heartland Institute, has received media attention in recent years for creating academic curricula discrediting the science

about anthropogenic warming, and distributing these curricula to public schools (Bagley, 2012).

While no teachers reported using these Heartland materials, in particular, I did notice that, rather than exclusively presenting facts pertinent to the first story (i.e. the scientific consensus on climate change), many teachers I interviewed *do* allow elements of the second story to appear in their teaching on climate change. They do this in a variety of ways and with a variety of intentions. What these teachers have in common, however, is that, in some way or another, they are presenting climate change as an issue with "two sides."

Only one teacher presented both sides as having equal scientific credibility. Not surprisingly, this teacher was Paul, the same teacher who doubted whether humans are solely responsible for global warming. According to Paul:

> I present both sides of it: 'Here's what geologists think. Here's what environmental scientists think.'… And then we do like a T-chart, basically—or a Venn diagram, whatever you want to call it, compare and contrast strategy—and then I have [students] actually debate about it: Which one do you think it is?

For Paul, it's important that students understand that some scientists see climate change as part of a naturally occurring cycle, while others see it as a human-induced phenomenon. "I don't view my job as giving my opinion," he explains, "I view it as me giving facts, having the kids argue about it, and letting them come to their own conclusions." It's also important to recall that Paul was one of the teachers who taught climate change "only briefly;" this single lesson, in which students compare and contrast viewpoints, is the only time when Paul directly addresses the subject.

Other teachers present evidence from both sides, but unlike Paul, they do not intentionally endorse skeptical views on climate change. For example, both Lauren and Olivia taught inquiry-based lessons where students had to research evidence both supporting and refuting the theory of climate change and use that evidence to defend a particular position on climate change. As a final project for her unit on climate change, Lauren required students to answer the question, "Are humans causing climate change or not?" According to Lauren, students "had to research and they had to provide the evidence about why humans are or are not causing climate change." Even though Lauren's lesson resembles Paul's somewhat, Lauren asserts that, "I'm definitely not like, a 'here's the information, you decide' kind of person;" unlike Paul, she affirms the anthropogenic causes of climate change and makes her stance known to students. Indeed, she hoped that, by researching both sides, students would likewise understand for themselves that climate change is real and caused by humans. At the same time however, by delegating students to research evidence for *and* against the theory of anthropogenic climate change, and by encouraging students to develop their own stance on the issue, Lauren is still supporting the notion that climate change is a story with "two sides."

Olivia's approach also acknowledged "both sides," but with some important differences. Similar to Lauren, Olivia had students research three claims: "climate change is human caused; climate change is not occurring; and climate change is not human-caused." However, unlike Lauren, who encouraged her students to choose and defend their *own* stance on climate change, Olivia actually assigned her students positions. "They didn't get to choose," she explains, "they just drew a number: 1, 2, or 3 out of a hat. So whether you believe what's on your card or not, that's the argument that you're

going to face and bring that in front of a panel." After researching the evidence for their assigned positions, students "sat on these small little panels and presented… what they found." After the debate portion of the activity, Olivia debriefed the whole class by leading a discussion explaining "some things that are facts and why [other things] might not be facts."

Olivia's approach is different from Paul's approach in two important ways. First, by assigning students positions (rather than letting students choose their own positions), Olivia tried to detach students from their preexisting biases. Secondly, by ending the activity with a debunking session (something neither Paul nor Lauren reported doing), Olivia is more explicit about the fact that "one side" of the story is false. However, it remains significant that Olivia acknowledged the "other side" at all. Neither she nor any other teacher reported adopting this approach when teaching about other issues. (For example, no teacher taught physics by having students analyze evidence supporting the theory of gravity as well as evidence opposing the theory of gravity). Again, teachers' differential treatment of climate change, compared to other topics, begs the question: What is it about climate change that necessitates teaching "both sides" when, scientifically speaking, there is really only "one side?"

Interestingly, the two teachers who declined to teach climate change at all, Hailey and Andrea, reported that if they *were* to teach climate change, they would choose a similar strategy where students analyze "both sides" in order to understand the scientific position. Explained Andrea, "I think the first thing I would do is to try to address their misconceptions. And they love, students love having roundtable discussions. They like stating their opinion. So I'd love to get some great texts that maybe have the science

behind it, and maybe uh, an opinion article or skeptic article and have them [the students] sort of decipher what's in that text and what's the data, and try to address some of those misconceptions." Similarly, Hailey thought back to some of her other lessons and recalled, "I've checked out some books before that have, like, pro and con arguments; they're short, persuasive essays by people and I use them for, like, alternative energy sources. And so I think something like that could be interesting to use [with climate change]." To clarify, I asked, "For like a 'pro and con' thing would it be like, 'Pro: this is why climate change is real. Con: this why we don't think so'?" Hailey confirmed, "Yeah."

It's important to note, again, that Hailey and Andrea aren't climate skeptics, nor do they intend for their students to become skeptics. Rather, they suggest that for students to understand and adopt the scientific perspective on climate change, the teacher needs to acknowledge and even engage the skeptical perspective, if only to debunk it. Again, this is significant because teachers don't report teaching other topics by addressing information that they themselves consider scientifically inaccurate. While the skeptic movement may not have succeeded in making climate deniers out of these teachers, it's possible they *have* succeeded in making teachers feel that students should study "both sides" of climate change. The way that these teachers very subtly validate the existence of doubt echoes, if somewhat dimly, the not-so-subtle attempts by the climate skeptic movement to manufacture doubt about climate change.

Other teachers entertained skeptical perspectives on climate change in more subtle ways. Dan, for example, recalled that when he taught climate change using *An Inconvenient Truth,* he would challenge students to critically discuss Al Gore's evidence,

asking, "'Is he [Gore] showing the whole graph? What is—is that graph really an accurate representation… is there anything about it that could be misleading?' So I try to more ask probing questions and then let kids kind of come to their own conclusions." While Dan didn't explicitly introduce skeptical material in class, he did encourage students to view Gore's argument suspiciously, and "come to their own conclusions," thereby implicitly validating contrarian arguments students may have heard outside of class.

In short, whether or not teachers *endorse* "both sides" of the climate change story, most teachers report at least *acknowledging* "both sides" in class. One might ask, is this approach good or bad? On one hand, the "both sides" approach could be counterproductive if it confuses students or validates scientifically inaccurate claims (whether intentionally or unintentionally). On the other hand, this approach could be productive if it ultimately leads students to better understand why the scientific consensus about climate change is valid and the skeptical perspective is flawed. (However, as I will point out in the next section, students do not always come to that conclusion).

At this point, however, my intent is not to argue that the "both sides" approach, in any of its forms, is a good thing or a bad thing; rather, I simply intend to point out that it's a *significant* thing. It's significant because teachers do not report taking this approach with other subjects. Indeed, even with other disputed topics, teachers tend to stick to a single, scientifically informed narrative, rather than addressing multiple "sides." For example, while many teachers reported controversies over topics like natural selection and age of the earth, no teachers reported even *entertaining* creationist arguments in class, let alone presenting them as having potential scientific validity. In some ways, the

practice of teaching "both sides" mirrors the "balance as bias" trend identified in the media, where journalists presented climate change as a "debate" long after scientists themselves had stopped debating it (Boykoff & Boykoff, 2004). Like journalists, teachers may be affected by the cultural climate of doubt surrounding global warming, and this climate, along with other facts (which I will address in subsequent chapters) may compel teachers to address contrarian theories, even though teachers themselves acknowledge such theories to be false.

There's a "Disconnect:" Doubts, Misconceptions, and/or Apathy Persist

Teachers from all different kinds of communities—urban, rural, liberal and conservative—consistently reported struggling to address students' doubts and misconceptions about climate change. Not only did students bring skeptical and/or inaccurate perspectives on climate change into the classroom, but in many cases these perceptions persisted even after instruction.

Persistent Misconceptions

Several teachers, for example, reported that their students struggle to distinguish between global climate change and perceived local weather patterns. Climate scientists are careful to note that *climate* refers to long-terms patterns of atmospheric conditions, while *weather* refers to the short-term behavior of wind, water, and air in the atmosphere, usually at a much more local level. This distinction is important because day-to-day weather fluctuations, while *related* to climate, aren't *evidence* of climate change (or lack thereof). Students, however, frequently fail to make this distinction. Dan reported that

"Kids like to talk a lot about 'global warming' as part of climate change and it's really hard to kinda differentiate, like, a heat wave, as opposed to global warming. Like, [students will say], 'It's really hot this summer, so it's global warming!' And it's like, 'Well, no, that's not exactly, those aren't necessarily correlated, you know?'" Gabby, too, notes that "they just don't believe it. So they're always, they always go, 'But it snowed so much this year!' And I go, 'Yes, because of global warming.' They go, 'Whaa?' So they just have, like, this huge disconnect…" Gabby, like other teachers, noted a "disconnect" between the information she's giving her students and the knowledge (or lack of knowledge) they, in turn, display about climate change.

As a participant observer at the State Science Teachers Conference, I attended a roundtable discussion about teaching climate change, where several teachers shared that their students, too, have persistent misconceptions about climate change. One participant suggested that teachers simplify it for students, by showing them an actual greenhouse and using it as an analogy for human-caused climate change. Another teacher responded, "I'm still struggling with student misconceptions," and that she'd tried this approach and students "don't understand how the actual greenhouse relates to the greenhouse effect." A third teacher agreed with the second, saying, "It's a maturity thing… it's totally a maturity thing."

Lauren expressed frustration that, even after several lessons on climate change, some students still failed to demonstrate their understanding of the science. In the previously described activity, where Lauren required students to write a paper about whether or not humans were causing climate change, students were inconsistent in their ability to cite valid evidence and come to scientifically accurate conclusions about this

phenomenon. “And it was so strange…” Lauren recalled, “One girl brought up all of these, like the increase in the amount of fires that are happening, and then she went around and was like, ‘We’re not doing anything.’” In other words, Lauren’s student was able to cite some evidence that climate change is occurring, but that evidence didn’t lead her to conclude that humans are the cause. Lauren recalled her exasperation with this student: “And I was like, ‘But I saw you research! You did research! How can you—?’ So, I don't understand how that didn’t, it didn’t connect for her.” Lauren’s statement, “it didn’t connect,” echoes Gabby’s assessment that students have “this huge disconnect;” for some reason, students continue to misunderstand aspects of climate science, even though some teachers, like Lauren, teach relatively comprehensive lessons on the subject.

These reports are consistent with a long list of studies documenting the persistence of student misconceptions about climate change (Gowda, Fox, & Magelky, 1997; Boyes & Stannisstreet, 1998; Andersson and Wallin, 2000; Boyes & Stannisstreet, 2003; Gautier, Deutsch, & Rebich, 2006; Kerr & Walz, 2007; Rye, Rubba & Wiesenmayer, 2007; Shepardson, Niyogibc, Choia & Charusombat, 2009; Boyes et al., 2009; Hansen, 2010; Jeffries, Stannisstreet, & Boyes, 2010; and many more). Jeffries, Stannisstreet, & Boyes (2010), three of the researchers who have been following trends in student knowledge of climate change for over ten years, repeated a ten-year-old survey of first-year college students and found that, a decade later, climate literacy among first-year college students had not improved; this new cohort of students expressed many of the same misconceptions as their predecessors, including the persistent conflation of climate change and the ozone hole. The authors gloomily conclude that, “despite media publicity and inclusion of the issue of global warming in the formal curriculum, insecure

knowledge and misconceptions persist." Rye, Rubba, and Wiesenmayer (2007) interviewed 26 middle school students two weeks after those students had completed a unit on global warming, finding that, even after instruction, students' "alternative conceptions" (i.e. inaccurate understandings) of the greenhouse effect persisted. Harker-Schuch and Bugge-Henrickson (2013) also examined European secondary students' conceptions of climate change before and after instruction and found that that while students' knowledge improved by 11% post-instruction, they still suffered from a poor understanding of the science; even with this improvement, students scored, on average, below 60% on a test of climate literacy. What's more, while instruction seemed to have a small effect on knowledge, it had no effect on students' opinions regarding climate change. For this reason, the authors perceive "an urgent need for improving climate change science education" (p. 755).

Persistent Doubts and Troubling Apathy

In addition to misunderstanding the science, many students simply reject it, as a matter of belief. Faith remarked, sarcastically, of her students, "Oh it's, it's *wonderful*, because more than half of my students don't believe in climate change." Gabby, too, reported that her students "are really sure it doesn't exist." For some students, doubt about climate change is religiously motivated. Olivia recalled one student who would "bring in scientific evidence from faith-based organizations" attempting to debunk climate change. According to Nicole, "a lot of kids just say, 'What will be will be; I don't have to worry about it because this is God's earth and He'll take care of me.'" Other students, like a few in Dan's class, cite their parents' views. Recalled Dan, "When we brought up things in

class, kids will come back and be like, 'My parents said... that you're feeding us a bunch of crap,' basically."

These skeptical views wouldn't be so troubling except for the fact that students often retain them, even after instruction in climate science. According to Faith, there's not much she can do about those students; "That's just, you know, they decide that they don't believe in it. And I have a few who, for evolution, decide the same thing." Elizabeth notes that, while she doesn't have "that many students that argue it," those who *do* argue are unlikely to be swayed by her unit on climate science. "And so," Elizabeth confirmed, "the kids who don't buy it, they're not going to buy it and they don't care."

Of course, not all students express skeptical beliefs about climate change. According to Brenda, most students "know all about it, they hear all about it, I think they're believers…" and according to Dan, "I think for the most part, in general, they kind of buy into the fact that it's occurring…" According to teachers' reports, plenty of students *do* demonstrate an accurate understanding of climate change and believe the scientific consensus that it's human-caused; however, the frequency and persistence of other students' doubts is enough to make teachers take note.

Teachers also expressed frustration about the fact that, even when students were able to demonstrate an accurate understanding of the science, they often failed to demonstrate any concern about climate change. In this way, too, there's a "disconnect." Explained Lauren, "elementary school kids, it's so easy to get them on board with stewardship science… and by the time you get to middle school they really just don't give a shit anymore. They can't think outside of themselves; middle schoolers are incredibly narcissistic." According to Faith, students of this age are "so 'me-centered!

In so many ways, they're just this perfect microcosm of the human race. We pretend to care about other things, but really it's all about us! We're all just middle-schoolers!" In response to sobering knowledge about climate change or other environmental problems, students might "feel very sad, but that's not going to get the kids off the couch." There's a sense of frustrated resignation in these teachers' reports: middle school students are "just kids," they're "so me-centered," they "don't give a shit anymore." If the goals of climate change education are partially normative—that is, interested in inspiring changed attitudes and behaviors as well as knowledge—then, by teachers' own admission, these goals are not consistently being met.

In summary, this chapter addressed the question of practice, concluding that while participating teachers generally agreed with the scientific consensus about climate change and expressed general concern about it, their reports revealed three potentially problematic trends in the classroom: 1) Many teachers spent a limited amount of time teaching climate change (despite their professed concern about it); 2) Teachers' pedagogical strategy often included presenting climate change as an issue with "two sides;" and 3) Teachers consistently expressed frustration with the challenge of getting students to correctly understand and/or express concern about this complex issue. This finding leads us to ask, what might keep teachers from delving more deeply into the subject? What makes teachers feel compelled to address skeptical arguments about climate change, and not just the scientifically sound ones? And, what might keep students from adequately mastering the material? The next three chapters attempt to answer these questions, by examining various pressures teachers experience in light of climate change teaching.

CHAPTER III

DIRECT BARRIERS TO CLIMATE CHANGE EDUCATION

I am by no means the first researcher to address the challenges of climate change education. A wealth of literature has examined various barriers that educators experience when considering teaching climate change. Mostly, these include direct barriers—for example, knowledge or resource deficits that prevent teachers from properly presenting the subject, or explicit pressure from administrators to avoid climate change or address skeptical perspectives alongside the science. These problems would seem to present the most obvious obstacles to climate change instruction.

In this section, I will draw from my own data as well as published studies to consider the degree to which direct barriers affect teacher practice and student learning. Specifically, I will address four factors that may explicitly limit teachers' ability to teach climate change. These include: teachers' own lack of knowledge about climate change, a lack of curricular resources, structural barriers within the educational system, and administrative pushback. Ultimately I will argue that, while these pedagogical barriers are consequential, they don't fully account for the experiences of teachers in this study. Specifically, direct barriers like knowledge deficits don't completely explain some of the more problematic trends I identified in Chapter II—particularly, challenges relating to making climate change "fit," teaching it as an issue with "two sides," and struggling to get students to properly understand and care about climate science.

Are Teachers Just Ignorant of Basic Climate Science?

A number of studies have found teachers suffering from patchy and/or misconstrued conceptions of climate science. For example, a persistent source of confusion for both schoolteachers and the public in general is the erroneous idea that global warming is directly connected to ozone depletion. A long list of studies (Groves & Pugh, 1999; Khalid, 2003; Papadimitriou, 2004; Boon, 2010; Hayhoe, Bullock & Hayhoe, 2011; and others) indicate that educators carry this and other misconceptions with them into the classroom. Research by Hayhoe, et al. (2011), for example, found that a majority of pre-service elementary teachers surveyed in Ontario thought that nuclear waste, along with "waste heat" from the burning of fossil fuels contributed to global warming (p. 257). These data are significant because they provide one possible explanation for the pedagogical problems of climate change; it could be that teachers' own ignorance of climate science makes them reluctant to address the subject and/or causes them to "pass their own misconceptions to pupils" (Papadimitriou, 2004, p. 300).

The teachers I interviewed did, on occasion, express concern about their own knowledge of climate science. For example, Olivia noted that, "As information and technology changes, to stay abreast of that is really difficult when you're in the classroom."

More often though, the teachers I spoke with demonstrated their scientific literacy and expressed confidence in their knowledge of climate change. While, in my own research, I made no direct effort to assess participants' knowledge of climate science, I can say that nothing in my fifteen interviews indicated that these teachers suffered from major misconceptions about climate science; for example, no teacher I interviewed

expressed confusion about the relationship between climate change and the ozone hole, or weather and climate. Paul, the one teacher who voiced some uncertainty about the cause of climate change, was the only participant to express any view that directly contradicted scientific consensus.

Another problem with the hypothesis that teachers "pass their own misconceptions to pupils" is that this hypothesis may not apply at the middle-school level. Most of the studies identifying knowledge deficits have assessed either elementary school teachers or teachers-in-training ("pre-service" teachers), not active middle school teachers—like those who participated in *this* study. Meanwhile, at least one study (Lombardi & Sinatra, 2013) confirms that, on average, active, secondary-level science teachers have a better grasp on climate science than their peers in elementary education or teacher-training programs. Interestingly, the study also compared middle school teachers who reported teaching about climate change with those who reported *not* teaching about climate change, finding that the two groups scored comparably on indicators of climate knowledge. This finding further suggests that knowledge of climate science (or lack thereof) does not predict middle school teachers' treatment of the subject.

Because both my own data and the existing literature suggest that middle school teachers may, in fact, be reasonably literate in climate science—certainly more so than the average person or the average elementary school teacher—I am unconvinced that a mere lack of knowledge explains why teachers de-prioritize the subject of climate change, or why students' confusion about the subject persists.

Are Teachers Limited by a Lack of Resources for Teaching Climate Change?

Whether or not teachers properly understand climate science, the inability to access educational resources could prevent them from adequately teaching the subject and hinder students' ability to adequately understand it. A 2011 survey of 1900 educators by the National Earth Science Teachers Association found that teachers express a strong reliance on outside resources and training for teaching climate change. When asked what would improve their ability to teach climate science, 54% mentioned curricular resources and teaching materials, 36% requested professional development, and 35% indicated a need for more current data and information (Johnson & Holzer, 2011, pg. 2). A separate survey, published by the broader National Science Teachers Association, also cited teachers' need for better resources. Said one educator, "Links to actual data sets that I could bring up to show students, or ask them to look at, would help a lot" (Petrinjak, 2011).

Despite some teachers' concern about insufficient resources, it should be noted that many resources *do* exist to aid climate science educators. One such resource is a guide to climate science education called "Climate Literacy: The Essential Principals of Climate Science." Created by a consortium of public and private agencies (including the US Climate Change Science Program, NASA, NOAA, and the NSF) this highly readable, 17-page document lays out what a collaborative panel of educators and scientists have deemed "the basics" in climate literacy; it is also based on the common-core standards, on which the NGSS are based. NASA, too, has also developed a separate website for educators called NASA Innovations in Climate Education; in addition to providing resources for understanding the Next Generation Science Standards and the Climate

Literacy Essential Principles, the website also offers peer-reviewed curricular resources, compiled data for use in the classroom, and online professional development seminars on various topics relating to climate education. There are even resources out there to help teachers handle the controversial aspects of climate change; the National Center for Science Education, which was originally formed to defend and equip teachers of evolution, now provides similar support for teachers taking on climate change. In addition to offering various resources related to the science itself, NCSE also provides tools for teachers responding to controversy over climate change. The resources mentioned here represent just a tiny fraction of the material available to teachers from federal and local agencies, nonprofit organizations, research institutions, science museums, and more.

While attending the State Science Teachers Conference, I again noted the opportunities for educators to learn about climate science and climate change pedagogy. Of the 88 hour-long breakout sessions offered, four of these sessions directly related to teaching climate change.

For anyone seriously seeking out resources for climate change education, there seems to be no shortage. Of course, it remains possible that teachers are unaware of these resources, can't easily access them, or feel they are unsuitable in some other way. Indeed, a few teachers in this study indicated that more resources for teaching climate change would be helpful. In explaining why she doesn't teach climate change at all, Hailey noted that climate change is "not something that my school has really tackled and we don't have good curriculum provided to us for it; and so if we want to do it, we're going to have to develop our own curriculum." Megan, Isaac, and Gabby all expressed frustration with

their assigned textbooks, which failed to address climate change in much depth. Gabby, for example, noted that climate change is "not really in textbooks yet" at all, and the one she uses "doesn't give good depth to what's going on." Beyond textbooks, Faith lamented that climate-related resources are lacking in general; "there are zero, like zero hands-on activities that anybody ever directs you to… other than, 'Look at the graph, with the little upturn… And that's why I come at it from the paleo focus, because that's what I know." For Faith, the challenge is not simply a *lack* of resources, but a lack of resources that fit her preferred method of hands-on instruction—a problem that I will address in more depth in Chapter V.

While teachers frequently mentioned the need for more resources related to climate change, it should also be noted that they had similar complaints about other subjects, too. Andrea, for example, lamented the lack of quality science readings for middle school students and insufficient funding for supplies to teach engineering. Hailey noted that textbooks are "terrible" for *all* her subjects, not just climate change. The lack of quality resources is a real problem for teachers; however, this problem isn't unique to the subject of climate change, which means it doesn't fully explain why teachers experience significant and distinct challenges with this topic.

What's more, my interviews revealed that, even though teachers sometimes wished for more resources, many of them were able to overcome this barrier, either by creating their own resources or utilizing outside sources. I was amazed by some teachers' resourcefulness when it came to educating themselves about various science topics and gathering the resources they needed to teach them. Andrea asserted, "that's something that I sort of thrive in; I'm sort of resourceful and can figure out how to make it work.

But it's a challenge. You know, you've got to go spend your own money. I have to go dumpster-diving." Another resourceful teacher, Lauren, dealt with a lack of curricula in evolution by developing her own, using stuffed animals to teach her students about natural selection and jelly beans to teach them about gene transfer. Lauren, Andrea, and others affirm that resource deficiencies can be a challenge for *any* subject, but one that can be overcome, if the teacher is willing to commit the extra effort.

Many teachers were similarly resourceful when it came to accessing or developing curricular materials related to climate change specifically. For example, several teachers described taking advantage of Youtube and other online resources to help them teach climate change. Explained Isaac, "teachers are getting away from textbooks… there's so much available on the internet… I think there's enough to do a focused unit [on climate change] at least a week or two." Elizabeth, Olivia, and several others made use of teacher professional development opportunities provided by outside organizations. Elizabeth recalled attending a session on climate change at a previous year's State Science Teachers Conference, where she received "this disk of PowerPoints and videos and resources" on climate change that she uses "all the time." Olivia, too, described participating in a teacher professional development program related to climate change. These reports from Elizabeth, Olivia, and others, undermine the assumption that teachers simply can't get their hands on the knowledge or tools they would need to teach climate change.

Curricular resources for teaching climate change do exist. What's more, teachers consistently demonstrate, via other subjects, that they are capable of accessing scant resources and/or creating new ones as necessary. That said, climate change is different

from other subjects; it is emotionally burdensome, politically controversial, intangible, and scientifically complex. These factors—which I will address throughout subsequent sections and chapters—may explain why teachers find existing resources to be insufficient, inaccessible, or unsuitable.

Do Structural Factors within the School System Limit Climate Change Instruction?

Even when teachers are themselves knowledgeable about climate change and able to access pedagogical resources necessary to teach it, they are not entirely the masters of their own classrooms; structural factors at the state-, district-, and school-level determine, in part, what teachers can include in their curricula.

State educational standards serve as one such factor. Kastens & Turrin (2008) examined educational standards nationwide and found that, as of 2008, all but one US state had science education standards, but only 30 included any mention of climate change. Fewer than 10 of those mentioned anthropogenic causes or mitigation efforts. This fact has led many, including McCaffrey & Buhr (2009) to note that "climate in general and climate change in particular continue to fall through disciplinary cracks and are often missing from state science education standards;" this fact is significant, since state standards "to a large extent drive what teachers must focus on in K–12 classrooms" (p. 514).

Until March of 2014, Oregon's science standards were somewhat vague on the subject of climate change. As described in Chapter I, these standards included some references to weather, climate, and human impacts on the environment at the middle school level, but didn't explicitly use terms like "global warming" or "climate change."

Certainly, a teacher *wanting* to teach anthropogenic climate change could have linked the topic to these standards. On the other hand, however, the same teacher could just as easily avoid the mentioning anthropogenic climate change without crossing official policy. In other words, while Oregon's longstanding standards don't exactly present a barrier against teaching climate change, they don't present a strong incentive, either.

As Oregon transitions to the Next Generation Science Standards (adopted in the spring of 2014), teachers may feel more pressure to include anthropogenic climate change in their curricula. As previously explained, these newer standards directly reference "global warming" and are explicit about the human causes and consequences of this phenomenon. Andrea, for one, indicated that this change might motivate her to address climate science where she hasn't before. She explained that with the new standards, "now, I have less fear about talking about climate change because it's explicitly stated."

When I interviewed teachers (during the summer of 2014) most reported that their schools were still in the early process of transitioning to the NGSS. This means that, if the new standards can be expected to increase or change teachers' treatment of climate change, that effect has yet to occur.

It's important, though, to not overstate the significance of state standards on the day-to-day practice of science teachers. State standards, by definition, provide a framework around which educators can build their curricula, but they do not constitute a curriculum in and of itself. The former Oregon standards address this fact directly, clarifying that standards "do not specify courses, teaching methods, or instructional materials" (p. 1). Rather, standards lay out a set of expectations regarding what students

of a certain age should know and be able to do. This holds true for the newer, Next Generation standards, too. A few teachers noted this accountability gap between official standards and classroom practice. This hands-off approach is especially relevant for smaller schools. Faith, for example, noted, "the good thing about small schools, is there's so little oversight, that I can almost do whatever I want."

My intention is not to imply that state standards have no effect on the way teachers address climate change. For some teachers, like Andrea, they may provide more incentive to include the topic. However, standards certainly won't dictate specific practices, like the kinds of materials, language, or lessons teachers should use when teaching about climate change; these decisions generally occur at the district- or classroom-level.

Another major structural factor for science teachers is the problem of disciplinary boundaries; in a disciplinary curriculum where science is segregated from math, language arts, and social studies—and science, in turn, is frequently divided into subsections of chemistry, physics, biology, and earth science—how do you teach a subject like climate change, which is inherently *inter*disciplinary?

Freierband, Jokmin, and Eilks (2011) address this question in a qualitative study of 20 German chemistry teachers. The authors found, just as I did, that while teachers unanimously affirmed the importance of climate change, they didn't consistently teach it in a substantial way. The authors note that:

> the number of classroom periods explicitly dealing with climate change among the majority of the interviewed teachers remains quite low. Only a handful of the teachers address climate change as a full, independent teaching unit equally ranked with other, more traditional topics in the chemistry curriculum. Most teachers deal with climate change solely in

> single classroom periods within units having their central focus on other topics (p. 88).

The authors attribute this pattern largely to structural barriers within the German educational system. Here, like in many US middle schools, science is taught in a disciplinary fashion, with chemistry, physics, and biology separated by classroom and/or grade-level. Because climate change is interdisciplinary by nature, teachers were hesitant about connecting it to chemistry-specific topics, like the periodic table. And, while certain aspects of climate change (i.e. combustion, ocean acidification) *are* relevant to chemistry, teachers were unsure whether students would understand these phenomena without first understanding relevant material in biology and physics. Rosanne Fortner comes to a similar conclusion in her 2000 assessment of climate education literature, noting that, "with an overcrowded curriculum and with little interdisciplinary training, teachers may be reluctant to infuse information about a topic that is inherently intangible and uncertain" (Fortner, 2000, p. 28). In this way, structural barriers like disciplinary boundaries might give literal meaning to teachers' claims that climate change "doesn't fit."

For teachers in this study, disciplinary boundaries *do* seem to affect practice. Gabby, one of the teachers who reported that she has taught climate change in the past but hasn't taught it recently, explains that her school used to teach science in an interdisciplinary fashion, where students studied some life science, some earth science, and some physical science in each grade. A few years ago, however, her school switched from this "spiraling" system to a "layered" system with life, earth, and physical sciences divided by grade. Gabby explained that she used to include climate change in her "weather unit, which we don't really do anymore because it got kind of pushed back

when we went to the layered teaching." According to Gabby, one of the reasons she is looking forward to the implementation of the NGSS is because, in addition to including more content about weather and climate, these new standards call for a return to the interdisciplinary, or "spiraling" model of science teaching at the middle school level.

Disciplinary boundaries also seemed to affect Nicole, who teaches both sixth-grade life science and eighth-grade physical science. Nicole frequently brings up climate change in her eighth-grade class ("weekly," according to her own estimation), but barely addresses the topic in sixth grade life science. Similarly, Kathy used to teach climate change, back when she taught eighth-grade earth science, because "Eighth grade's supposed to do weather." Now, however, she teaches seventh-grade life science, where the connection to climate change seems weaker. While there's no reason science teachers *couldn't* teach climate change in the context of biology—indeed, Kathy acknowledges several units where it could theoretically fit, including natural resources and fossil fuels—it could be that teachers feel they needn't address it in one grade if it's already being addressed in another grade.

Teachers cited other structural barriers as well—large classes, short periods, and too many curricular requirements, to name just a few. These factors, while challenging in the context of *any* subject, could be especially challenging in the context of complicated, interdisciplinary topics like climate change, particularly if teachers already feel pressured by insufficient resources or other, social and cultural factors. Said Brenda, "Our calendar year has become so short and our curriculum expectations are so broad…" Elizabeth and others cited the problem of time: "other teachers I've talked to, they don't have time. It's like, okay, we're going to do climate change: boom, boom, boom, boom, boom … I've

got an hour a day to plan for four classes… So, it's just never enough time in the day. It's just terrible."

These structural barriers, like those presented by state standards and disciplinary boundaries, certainly pose a challenge to teachers. However, just as teachers were adept at overcoming a lack of curricular resources, many teachers demonstrated their ability to overcome structural barriers too, teaching complex, interdisciplinary subjects even when factors like grade-level divisions and bell schedules might discourage them from doing so. Dan, for example, helps organize *thirty* different environmental science field trips for his school, ensuring that every student gets out in the field multiple times per year. On these trips, students are assessing stream health, doing botany transects, collecting marine debris, and more. When I asked Dan how he managed to accomplish this kind of field-based, interdisciplinary teaching, given the constraints of time, money, and bell schedules, he responded, "I think just, you know, it takes passion from a teacher. It takes a lot of extra kind of personal time, to do those extra things that are really gonna get kids engaged and make a difference in the environment." Once again, this indicates to me that structural barriers are not insurmountable, and thus fail to fully explain why some teachers fail to "fit in" climate change.

In short, structural realities may partly, if not fully, justify teachers' claims that climate change "doesn't fit." However, these same structural factors don't logically explain why, when teachers *do* teach climate change (whether briefly or extensively), they tend to engage "both sides" and why students, in turn, retain persistent doubts and misconceptions about the science.

Administrative Pushback: Are Teachers Explicitly Pressured to Avoid Climate Change or Teach It in a Particular Way?

A wealth of popular news articles has documented conflicts over climate change in the classroom, both at a local and statewide level. Louisiana and Tennessee, for example, have made headlines in recent years for passing legislation protecting teachers' right to present skeptical perspectives on both climate change and evolution (Morello, 2013). Similarly, in South Dakota, the state legislature passed Resolution No. 1009 in 2010, urging that "instruction in the public schools relating to global warming" include the principle that "global warming is a scientific theory rather than a proven fact" and that the study of various impacts to "world weather phenomena" is "largely speculative." Teachers in these states are experiencing direct, administrative impositions pressuring them to either avoid the topic or address "both sides."

These kinds of pressures are also occurring at a local level. In 2011, the journal *Science* made the worrisome observation that the "U.S. political debate over climate change is seeping into K–12 science classrooms, and teachers are feeling the heat." The article highlighted several cases where teachers experienced administrative pushback over the subject of climate change. In one case for example, a school board in southern California (led by a conservative climate skeptic) passed a new policy "requiring teachers to explain to the school board how they are handling such topics in class in a 'balanced' fashion" (Reardon, 2011, pg. 688). This policy effectively required teachers to leave room for doubt when teaching about anthropogenic climate change.

Having read reports of legislators, administrators, and parents successfully pressuring educators to teach (or not teach) climate change in a certain way, I was

prepared to hear many similar stories from the participants in this study. However, I heard very few. While all fifteen teachers I interviewed that either they or a peer had experienced disagreement with a parent, colleague, or student over the subject of climate change, no teachers reported being explicitly barred from presenting the subject, nor given a mandate to teach it in any particular way.

This finding contradicts the message of popular news reports, but corroborates the findings of other academic studies; for example, a survey by Wise (2014) found that, in response to the question, “Has anyone suggested to you, that you should NOT teach about global warming?” 87% of 183 earth science teachers responded, “No one.” The 2011 National Science Teachers Association Survey, mentioned earlier, indicated that while 82% of teachers had “faced skepticism” from students, only 26% had faced skepticism from administrators.

According to teachers in this study, students often presented skeptical perspectives during class, and while these claims served as a frustrating reminder of students’ persistent doubts and misconceptions about climate change, they did not create major conflict in the classroom. Some teachers, including Megan, just laughed about it: “kids you know, sometimes just ridiculous things will come out of their mouths and you know that they’re hearing it from home.” A student might say, for example, "Oh, well, it was a colder-than-usual winter, so climate change is just stupid…” Interestingly, there was no observable correlation between a teacher’s location (i.e. rural, urban, conservative, or liberal) and the likelihood of encountering skeptical claims from students; all teachers reported encountering such claims on occasion.

Teachers in this study also reported occasional pushback from parents. Again, however, this kind of conflict was usually brief and mild, and it almost never involved administrators, or anyone else with authority. Even Elizabeth, who works in a small, rural town, noted, "I haven't had—surprisingly, being a conservative community as they are—I haven't had much. I can't think of a parent that insisted, 'I don't want my student taught this!'" Recalled Brenda, "only one time I did, maybe 3 years ago, get some fallout from a parent… a student had taken this article home to read on climate change and rising temperatures and [the parent] wrote all over it and said, 'you're teaching our kids—you know, whatever.'" I asked Brenda, "How did you respond to that?" Brenda laughed, "I didn't! You know, I just didn't respond to it. And he didn't—this parent didn't follow up on demanding a response to it." Isaac also experienced some pressure from parents seven or eight years ago, when "one family, extremely conservative, called me into the principal's office" after he showed a Tom Brokaw special on climate change. Isaac recalled that "the principal and we had to talk it over and nobody was happy, but I wasn't told not to [teach it]." The parents "made their position clear that they didn't believe it and they thought it was a bunch of baloney and, you know, [the situation] passed. I didn't like it, but it passed." Isaac proceeded to teach his lesson, as planned.

The only respondent to report experiencing significant pushback for teaching climate change (or any other topic, for that matter) was Carly. Carly lives in a fairly liberal city but works thirty minutes away, in a small, conservative town. Noted Carly:

> It's definitely controversial in our community. Definitely controversial in our community. And definitely I've had some parent calls that said, *[here Carly adopts the low-pitched voice of a stern, male parent]* "You don't have to teach *that*. You shouldn't be teaching that sort of a thing."

Carly recalled that several years ago, “we had a very religious principal, from a church that doesn’t support global warming. And so the people who belonged to this church were very able to target me.” She was placed on drop-in observation three times per week. Notably, Carly was targeted not solely for her treatment of climate change, but for other subjects too, including such seemingly banal topics as invasive species. While this intrusive monitoring undoubtedly affected Carly’s treatment of sensitive topics, including climate change, it didn’t ultimately prevent her teaching them, nor did she suffer any actual disciplinary action. I asked Carly, “When you do get that sort of pushback… how do you respond?” Carly paused, adopted an expression of serene humor, and replied, “Deep inside I smile.” We both laughed. Fortunately for Carly (and for her students), the contentious principal later left, and has since been replaced with an administrator more supportive of her curriculum.

In fact, all the aforementioned incidents of conflict occurred in the past, and several teachers expressed that negative pressure from parents or administrators has become even less frequent in recent years. This trend corroborates data from the National Earth Science Teachers Association survey, which asked teachers how attitudes about climate change have changed in their school; the authors report that 50% of teachers indicated an increase in positive attitudes, while 27% indicated no change, and only 12% indicated an increase in negative attitudes (Johnson & Holzer, 2011). Isaac, the same teacher who was called into the principal’s office by angry parents more than seven years ago, matter-of-factly affirmed, “*Now*, of course, I think it's not an issue for schools to teach about climate change.”

Unlike teachers in South Dakota facing a congressional resolution on climate ambivalence, or the teacher in California whose school district pressured him to teach climate change in a "balanced way," teachers in this study reported that, if anything, they felt supported rather than undermined by their administration. During Isaac's one experience of climate-related conflict, the principal supported his decision to teach the subject, even in the face of an angry parent. Andrea reports, similarly, that if she were to ever get pushback from parents, she'd feel confident turning to her administration for support, "Because that's the principal's job… administration is the buffer and I don't need to take that."

It seems, then, that teachers in this study have been spared the kind of direct, negative pressure that would compel them to avoid climate change, teach it in a superficial fashion, or teach "both sides." That's not to say that the ongoing cultural controversy surrounding climate change doesn't affect whether and how these teachers choose to address climate change. Rather, social controversy over climate change has an *indirect* impact on teacher practice—an effect that I will further explore in subsequent chapters.

Thus far, I have described four relatively tangible barriers that would directly impede climate change education: teachers' lack of knowledge, resource deficits, school structure, and direct pressure from administrators or community members. While these barriers to climate change education are consequential, they don't fully account for the problematic trends in practice I identified earlier. Why not? For one, teachers didn't experience these direct barriers on a consistent basis; sometimes the problem didn't even occur. Secondly, when teachers *did* experience direct barriers to climate change

education, they often experienced the same barriers in the context of other subjects, too; thus, these problems aren't unique to the subject of climate change. Thirdly, whether the barrier was unique to teaching climate science or not, teachers were often able to overcome it; thus, these explanations in and of themselves are insufficient. For these reasons, we cannot blame the pedagogical challenges of climate change solely on direct barriers, like faulty knowledge, insufficient resources, or unsupportive administrators. In the next chapter, I will turn from direct barriers to emotional factors that may indirectly influence the way teachers address (or fail to address) the subject.

CHAPTER IV

EMOTIONAL PRESSURES AND CLIMATE CHANGE EDUCATION

Why would teachers who are both informed and concerned about climate change—and who are under no direct pressure to teach (or not teach) the subject in any particular way—continue to report that climate change is difficult to fit in, or that students have difficulty understanding it? The literature on environmental education and the sociology of climate change suggest that individuals and communities experience various emotions related to climate change and that these emotions have a complex effect on beliefs and actions. While tangible factors, like the availability of resources, may affect teacher practice in a direct fashion, these more intangible emotional pressures—for example, teachers' desire to avoid conflict or manage students' emotions—affect teaching in a more indirect fashion.

Here, I will draw on my own research as well as other published studies to identify some of the significant emotional pressures that teachers experience in the context of teaching climate change, and illustrate how these pressures may account for some of the challenges teachers face regarding climate change in the classroom. These pressures include teachers' own emotions about climate change; managing students' emotions; and fear of interpersonal conflict.

Teachers' Own Emotions

Throughout my interviews, teachers expressed a variety of emotions about climate change, most of them negative. A minority of teachers explicitly shared feelings

of fear or sadness, while a majority of teachers referenced feelings of guilt and/or personal responsibility.

Feelings of Fear or Sadness

Three teachers expressed feelings of anxiety about the effects of climate change. Olivia, whose husband works in wildfire management, reported, "I'm definitely fearful. Even because of my personal connection to the wildfire. And the communities that are impacted… and people being evacuated and homes being burned. I mean, there's definitely a fear factor." Gabby expressed her fear about how climate change may impact food production; "I guess for me," explained Gabby, "I'm more worried about agriculture and how agriculture is going to deal with climate change… that's going to be really hard." Nicole, too, worried about her family members, who are farmers in the Midwest, wondering how their lives would be impacted by climate change. In fact, Nicole, more than any other participant, expressed deep emotion about climate change throughout our interview. Referring to ocean acidification, she admitted, "it's pretty horrifying what's going on in the oceans right now. Pretty abysmal... just, very depressing. Very depressing." Nicole also reported that talking about climate change with her close friends and family gets her "all fired up. And we just get so frustrated. And we're like, 'Are we the only people that are awake in this world?' Like, 'What the hell is going on out there?!'" Nicole isn't just concerned about climate change; she finds it "horrifying," "depressing," and incredibly "frustrating." Though just three teachers explicitly expressed such feelings of fear or sadness, the intensity of their feelings was significant, and worthy of note.

Feelings of Personal Responsibility

More than fear, though, the topic of climate change inspired teachers to express feelings of personal responsibility, particularly in relation to their own, individual actions. One question that I asked nearly every interviewee was, "I'm curious, when you're not teaching, whether you think much about climate change?" I framed this question broadly, in order to avoid suggesting whether or not respondents *should* be thinking about it, or what sorts of thoughts and feelings they should have. After about five interviews, I noticed a pattern, which continued throughout my research. More often than not, teachers would immediately respond to this question, not by describing their political position, their views on the science, or fears they may have about the consequences of climate change, but by assessing the personal actions they were or weren't taking in response to the problem of climate change.

When I asked Elizabeth if she thought about climate change, she immediately responded, "Yes, from the standpoint that I drive a little car." She then went on to describe how she line-dries her clothes, carpools, and tries to cut back on resource use. She admitted that, while she also owns a large truck, she needs it to pull her horse trailer—unlike "the guy down the road who drives this big, three-quarter-ton diesel and commutes back and forth to work in it." Here, Elizabeth conveys feelings of pride in defense of her environmentally friendly behaviors (especially in contrast to her gas-guzzling neighbor) while at the same time admitting some guilt about her own large vehicle. For Elizabeth, "thinking about climate change" means thinking about her personal impact and responsibility.

When asked whether she thinks about climate change, Olivia responded, "Oh, often," and then described a personal sacrifice she had recently made in order to reduce her carbon footprint; in the last year, she moved away from a town she loved to a new, less desirable town in order to shorten her commute. At the same time, Olivia also described feeling bad about other personal impacts, like flying—"which goes against some things"—and about not riding her bike as often as she used to. "So I try to think about everything," she explained. "Sometimes it actually consumes me—it consumes me, I think." Olivia's response suggests there can be some comfort in dwelling on personal pro-environmental behaviors: At least I'm doing my part! However, thinking about climate change as a matter of individual responsibility can also be overwhelming, or, in Olivia's words, "consuming." It's a heavy emotional burden.

Six other teachers, including Dan, Hailey, Kathy, Isaac, Paul, and Gabby described "thinking about climate change" in ways that affirmed their feelings of personal accountability. Notably, teachers were equally likely to cite their individual responsibility for climate change whether they lived and worked in a liberal, university town or a more conservative, rural community. Though they didn't use Olivia's emotionally charged language, these teachers still conveyed a sense of emotional tension as they defended their pro-environmental behaviors in one breath, while somewhat sheepishly admitting their environmental shortcomings in the next breath. Isaac responded, "I don't obsess on it, for sure… [just] being aware, and within my own life I do everything that I can think of; but I still drive to [nearest large city] to get my groceries monthly." Even Paul, who seemed the least concerned about anthropogenic climate change, cited his personal pro-environmental behavior, as well as its limitations:

"It's—you know, I'm not running into [town] every day, driving everywhere. When possible I cut back. And we live on a farm so we use a lot of our own stuff, we don't go buy things." When asked whether she thinks about climate change, Gabby, similarly, responded with "Um, I *try* to. [Laughs lightly] I try to be really careful about my energy usage and that sort of thing, but... [trails off]." Gabby's self-conscious laughter and unfinished sentence could signal feelings of ambivalence or discomfort regarding her personal contribution to climate change.

Again, it's worth noting that, in all of these cases I simply asked the respondents whether, outside of the classroom, they thought much about climate change; I never intentionally prompted them to discuss their personal environmental behaviors. It's as if, when teachers heard, "Do you think about climate change?" they automatically interpreted the question to mean, "Are you thinking about how your personal lifestyle contributes to climate change?" In this way, participants turned an open-ended question meant to gauge teachers' interest in climate change into a test of individual morality and behavior.

In the context of emotional pressures, this is significant. It's significant that teachers frame climate change as an issue of individualized responsibility because, while this feeling of responsibility may inspire some pro-environmental behavior changes, this same feeling of responsibility may also inspire uncomfortable emotions like guilt, ambivalence or hopelessness. These negative emotions may be amplified when one contemplates, as Olivia does, the enormity of climate change compared to the insignificance of one's own personal attempts to reduce carbon emissions. The result can be emotionally overwhelming.

Emotions Affect Teaching Practice

How then do negative emotions like fear, guilt, or sadness relate to the pedagogical trends I described in Chapter II? For example, how might emotions reinforce—or counteract—teachers' feelings that climate science is hard to "fit in?" Environmental educators, psychologists, and sociologists have long maintained that emotions significantly affect the way that individuals respond to phenomena like climate change; however, they are not all in agreement about how this effect works.

On one hand, teachers' own feelings of fear, sadness, or personal responsibility could positively motivate them to address climate change in the classroom. Indeed, in much of the literature on environmental education and behavior, there is an implicit (and sometimes explicit) assumption that emotions can promote pro-environmental attitudes and behavior. One article from *Environment and Behavior*, for example (boldly titled "Environmental education and attitudes - Emotions and beliefs are what is needed"), claims: "it is what people feel and believe about the environment that determines their attitudes toward it" (Pooley & O'Connor, 2000, p. 711). Similarly, Kollmuss and Agyeman (2002) suggest that "an emotional connection seems to be very important in shaping our beliefs, values, and attitudes towards the environment…" Kollmuss and Agyeman go on hypothesize "that the stronger a person's emotional reaction, the more likely that person will engage in pro-environmental behavior" (p. 245). In the context of climate education, this argument is significant because it proposes that emotions—even negative ones—may encourage teachers to engage in pro-environmental behaviors, including educating their students about this subject. For teachers who feel some guilt or ambivalence about their own contributions to climate change, educating others may be an

activity (alongside recycling and carpooling) that helps to satisfy their feelings of personal responsibility. Feelings of fear or sadness, too, may provide a sense of urgency or purpose to this task.

Within this study, participants' reports occasionally supported this hypothesis, suggesting that negative emotions may indeed encourage teachers to address climate change. According to Nicole, "So with [my eighth-graders] I always talk about climate change—at least once a week. *Because it scares the heck out of me*" (emphasis mine). Nicole continued, "And I want them to know what's going on. I want them to know what contributes to climate change. And I want them to know what they can do to take some responsibility in it all." Indeed, Nicole was one teacher who *did* teach climate change in her eighth-grade class. Similarly, Megan suggested that her own sadness about climate change influenced her decision to address climate change with her students, even though it isn't a primary topic of focus. She explained, "there's real people losing their homes and there's real animals being threatened and there's real stories that [students are] just not hearing because people don't want them to hear it… I just want them to know that they have a personal responsibility to learn about this stuff." Both Megan and Nicole suggest that their decision to teach climate change is influenced, in part, by their own strong emotions about the subject.

While some environmental educators and researchers point to the way emotions may positively influence teachers' treatment of climate change, other scholars suggest the opposite, noting how emotions, particularly negative ones, may actually *discourage* people from facing difficult topics like climate change. In this way, negative emotions may explain some teachers' tendency to avoid or minimize the subject, a choice which

they may justify by claiming that climate change is difficult to "fit in." A survey-based study by Lombardi and Sinatra (2013), for example, found that teachers who indicated greater feelings of anger about climate change were less likely to teach the subject than those who did not indicate such feelings. The authors also suggest that other emotions may negatively influence teaching practice. "Hopelessness," for one, "could also result in teachers failing to engage because they may have a perceived inadequacy to influence future outcomes" (p. 184). Again, teachers may avoid the topic, not because they feel *no* personal responsibility for climate change, but precisely because they feel an *acute* sense of personal responsibility, but lack the means to fix the problem themselves. Individuals may be inclined to deal with this cognitive dissonance by doing the small good deeds they can, while avoiding the subject of climate change beyond that.

Sociologist Kari Norgaard's research on climate change non-participation in Norway and the US (2011) also suggests that negative emotions like fear, guilt, and hopelessness motivate individuals to avoid this issue in thought, conversation, and action. She observed that, even though Norwegians understood and cared about the problem of climate change (just as teachers in this study do), they rarely talked about it or engaged in meaningful responses to the problem. In the words of one Norwegian man, avoidance is one way that people "protect themselves a bit" from negative feelings associated with climate change (p. 4). Rather than confronting the enormity of the problem—a problem that individuals may feel powerless to address—people simply avoid thinking and talking about it.

One teacher explicitly addressed this inverse relationship between concern and action. Megan, the same teacher who earlier asserted that both she and her students "have

a personal responsibility to learn about this stuff" also acknowledged the converse—that the subject of climate change is "uncomfortable. It's hard to think about. It's hard to think that we're destroying the earth, or whatever. That's a tough topic. We'd rather just not look at it. It's way easier."

In the context of science teaching, this perspective would suggest that teachers may avoid teaching climate change in order to avoid their own feelings of sadness, fear, or guilt. Instead, teachers may prioritize science topics that *don't* inspire these same negative emotions—topics like dinosaurs, the water cycle, or covalent bonding; teachers may work harder to "fit in" these emotionally neutral or emotionally upbeat topics.

In summary, while it's clear that teachers experience negative emotions in response to the problem of climate change, it's unclear whether these emotions motivate teachers to address or avoid the topic in the classroom. That is, it's uncertain whether negative emotions contribute to teachers' belief that climate change is hard to "fit in." The effect of emotions on teacher practice is complex, and deserves more direct study; however, I propose that emotions both positively *and* negatively influence the inclusion of climate change in the classroom. Specifically, it could be that teachers' feelings of fear and personal accountability motivate them to bring up the subject in class—after all students, like teachers "have a responsibility to learn about this stuff"—but these same emotions may discourage teachers from dwelling on the subject too long or too deeply. This may explain, perhaps, why many teachers report addressing climate change, but only briefly, or only in the context of other topics.

Managing Students' Emotions

Teachers in this study, including Megan, confirmed that climate change "can be scary to kids. They don't want to hear that kind of stuff." Nicole agreed, noting, "oh God, it's so depressing. They [the students] get so depressed." Olivia and Kathy recalled incidents when students reacted emotionally to learning about other environmental problems as well. One student in Olivia's class, for example, learned that the subdivision he lived in was built by razing a former apple orchard. According to Olivia, "He [the student] actually felt awful, he was like, 'Oh my God! How do I change that?'" In Kathy's case, a student "was just beside himself" over an assembly about waste reduction; after learning how much waste humans generated, the student felt that the problem was just too big to solve. Kathy recalled, "He was so *upset* about it."

So in addition to experiencing their own emotions, teachers recognize that students, too, may have feelings of fear, sadness, or guilt in response to difficult environmental topics, including climate change. A few teachers expressed concern about making their students feel bad. According to Andrea, "I feel like once people start feeling guilty, they begin to shut down," and so teaching about environmental issues like climate change requires "empowerment without guilt." At the State Science Teachers Conference, the moderator of one session on climate change education put it succinctly: "You have to have a balance between hope and despair." Several participants echoed this sentiment.

A surprising number of teachers, however, expressed no regret about causing their students emotional distress. When asked whether he takes into account students' emotions when teaching a potentially depressing or guilt-ridden topic like climate

change, Isaac responded, “I do. But I don’t *not* teach it because of that.” Similarly, when I asked Brenda whether she ever worried about making students feel scared or sad when it comes to environmental problems, Brenda responded, “…in terms of upsetting them?… I don’t think I’ve ever pulled the punches on that one.” Several other teachers responded along similar lines:

- “I don’t feel bad about making them feel bad…I think they should feel bad” (Kathy)
- “They need to be scared… Our students are pretty privileged, for the most part, so scaring them is not a bad thing” (Gabby).
- “I mean, I say on a fairly regular basis to all of my students that we're all going to kill ourselves. That humans are going to destroy themselves” (Lauren).
- “They will tell you, I sock it to ’em… why sugar-coat it? … I throw distressing stuff to them all the time” (Elizabeth).
- “I just show it to them, saying, ‘This is what it is!” (Carly).

Nicole reported taking a similar doomsday approach, explaining that if I were to interview her students and ask, “Did Mrs. N teach you about climate change?” the students “would look at you and be like, ‘*Yeah*.’ Especially my 8th graders. They would all probably say ‘Yeah, Mrs. N made us feel like the world is going to end every day.’” But rather than trying to minimize her students’ emotions, Nicole reported, “I actually take advantage of the feeling. At least they're feeling something, even if it's not positive…they also really tune in when it’s, like, doomsday stuff.”

These reports suggest that, far from shying away from students' emotions, these teachers seem to embrace making their students feel bad about environmental problems, including climate change. In fact, these teachers strategically manage students' emotions, arguing that negative emotions may actually enhance student learning.

Students' Response to Negative Emotions

Again, how might this emotion-related pressure account for the pedagogical trends I identified regarding climate change in the classroom? If teachers' *own* negative emotions about climate change don't prevent them from teaching the subject, it could be that their willingness to make *students* feel scared, sad, or guilty is actually counterproductive; faced with these negative emotions, students may tune out, or worse, bolster their own doubts and misconceptions about climate change.

Again, Kari Norgaard's research in Norway and the United States sheds light on this phenomenon. The way one Norwegian teenager described it, "I think that there are a lot of people who feel 'No matter what I do, I can't do anything about that anyway'" (pg. 82). According to one American student, "solving global warming seems like such a daunting task, and even I know that it can seem too overwhelming" (pg. 4). Like with the adults Norgaard surveyed, these students' bleak emotions were associated with apathy, rather than conviction and action. Maria Ojala's research into young peoples' means of coping with climate change (2012) makes a similar connection between negative emotions and disengagement from environmental issues. According to Ojala, "emotion-focused" coping—whereby distressing information is mitigated through a process of

denial, rather than action—is associated with both decreased pro-environmental behavior and decreased life satisfaction (pp. 226-7).

In addition to affecting how students *act* in response to climate change, emotions may also impact what students *believe* about climate science to begin with. One incident from Lauren's class is telling. As described in Chapter II, Lauren had instructed her students to research the possible causes of climate change and then write a paper explaining "why humans are or not causing climate change." Lauren recalled that several students defended the skeptical view that humans aren't responsible—but these students "had very, very poor reasons." These students, it seemed, rejected the theory of anthropogenic climate change for personal, emotional reasons, not scientific ones. According to Lauren, the students' arguments boiled down to, "'We're just not doing anything. It's not my fault.'" Recalled Lauren, "That's really what it came down to is, *I'm not doing anything*. It's not that *we* aren't doing anything, it's that I.. *I* am not doing anything, so [therefore] *we* are not doing anything."

Lauren's students seem to be demonstrating the "emotion-focused" coping strategies Ojala referred to. For these students, the theory of anthropogenic climate change came with an implicit accusation of personal responsibility: Humans are guilty of causing this enormous problem, and *you're* guilty too. Because this moral accusation seemed unbelievable, emotionally untenable or both, students instead gravitated towards the scientifically inaccurate but emotionally tolerable conclusion that "we" are *not* to blame for climate change.

While Lauren's case is just one out of many, it may serve as a cautionary tale about the role of emotions—particularly negative emotions like fear or guilt—in climate

change education. Teachers, in their willingness to "make students feel bad," may be overestimating students' ability to cope with negative emotions. Rather than inspiring students to pay more attention, to learn more, and to care more, these negative emotions may actually lead students to shut down, or to defend inaccurate ideas about climate change. This phenomenon may explain, in part, the resistance of students' doubts and misconceptions to instruction.

Fearing or Avoiding Interpersonal Conflict

Just as teachers and students experience emotions in response to the phenomenon of climate change itself, so too do they experience pressures in relation to the social controversy surrounding climate change. The desire to avoid conflict may indirectly pressure teachers to avoid teaching about climate change, teach it in a superficial fashion, or teach "both sides." In addition, teachers' efforts to avoid conflict may indirectly contribute to students' misconceptions and doubts about climate science.

Earlier, I reported that teachers rarely experienced conflict over the subject of climate change and that when they did face pushback, it was brief and mild. With the possible exception of Carly (the teacher who was placed on drop-in observation), no teacher was forced by colleagues, parents, or administrators to adopt or abandon any particular teaching practices. Does this fact indicate, however, that social controversy has no effect on the way teachers and students engage with climate change? In short: no. Teachers in this study fully recognize that climate change remains socially contentious and as such, they try to avoid conflict with parents, students, and colleagues whenever possible. Indeed, I would argue that part of the reason teachers *don't* report experiencing

major battles with parents, principals, or school boards is because they are adept at preventing conflict before it occurs. Teachers' strategies for avoiding conflict, in turn, may contribute to the notion that climate change is hard to "fit in." Conflict-avoidance may also explain, in part, why teachers admit evidence from "both sides" and why students, in turn, continue to harbor doubts and misconceptions. In this way, social controversy serves as an indirect, rather than direct, barrier to climate education.

Existing literature supports the notion that teachers worry about interpersonal conflict over climate change, and that they significantly or subtly adjust their teaching practices so as to avoid this conflict. A 2011 survey by the National Science Teachers Association reported that teachers "noted the political polarization of climate change education and the effect on their teaching." For example, one middle school teacher from Wisconsin wrote, "I'm concerned that parents will challenge the material that is included in my curriculum. I focus on having students examine data and draw their own conclusions." This seemingly small adjustment—focusing on the data and letting students make their own conclusions—may prevent conflict with parents, but may also have consequences for what students ultimately come to understand about climate change.

Wise's 2010 study asked teachers, "Do you use any specific strategies when teaching about global warming, due to the fact that it is publicly controversial?" Among earth science teachers who taught formal lessons on climate change, many of them reported that they: emphasize the nature of science aspect of the topic (87%), acknowledge and/or allow discussion of ideas expressed by global warming skeptics (76%), offer to talk with students outside of class (24%), and/or send a letter home to parents (14%).

A 2004 study by Griffith and Brem examined how teachers coped with another socially controversial science topic: evolution. In this context, too, the authors found that fear of conflict may discourage teachers from addressing the contentious topic and/or cause them to modify their teaching practices. The authors describe how one teacher, in particular adjusted her teaching in this context:

> [She] acknowledged that when she teaches evolution, her teaching style changes. She begins other units with open discussion and encourages students to find personal relevance, but when she teaches evolution, she 'sneaks it in.' She tolerates no discussion, the format of the class becomes lecture only, and she does not even use words such as ''evolution'' until they are well into the unit in hopes that this will reduce the number of opportunities students have to disrupt the class or to tell their parents that they are studying evolution in school.

As I will illustrate, teachers in this study adopted some of these same conflict-mitigating tactics when teaching about climate change.

Pedagogical Strategies for Avoiding Controversy

Some teachers avoided conflict by avoiding the topic altogether. Interestingly, the two teachers who seemed most concerned about inciting controversy over climate change were also the youngest participants in this study. Andrea and Hailey, both first-year teachers, declined to teach climate change at all, in part because of their worries about disputes with parents, students or both. It should be noted that neither teacher had ever personally experienced conflict over teaching climate change; however, the perceived risk of conflict was enough to steer them away from the topic. Explained Andrea, "I feel like as a new teacher in a new community I wasn't really sure, and I heard horror stories about mentioning [climate change] and, you know, calls from parents." While Andrea

worried about clashes with parents, Hailey worried about her students. When I asked Hailey if she ever mentioned climate change in class, she explained:

> I didn't this year, and for multiple reasons. Partially because I think it—we have a population of students that are, some of them are quite conservative… and I had a group of kids that I was having a hard time managing well at the beginning of the year and that was not something that I felt comfortable tackling.

Hailey feared that, by introducing a potentially controversial issue like climate change, she would lose control of her already unruly and politically conservative students.

Paul, the one teacher who wasn't sure whether climate change was natural or human-caused, reported that one of the reasons he limited his instruction on climate change was to avoid conflict with a coworker who was even *more* skeptical than him. According to Paul, this fellow teacher "basically said it was just part of the earth's natural, geologic processes," and didn't give any credit to the theory of human-caused warming. Paul confronted the other teacher, and "we agreed to disagree and agreed to not really go into depth on it because we're very different… and we didn't want to be arguing in front of the students." Paul, Hailey, and Andrea all suggest that *fear* of conflict—rather than the actual experience of it—may explain why teachers avoid or minimize the subject and insist that it's hard to "fit in."

Other teachers avoided conflict by exercising special cautions when dealing with climate change. According to Megan, "it's all about the relationship that we have with the kids and the parents and whether they trust you or not." She added, "I just think sometimes you have to be careful with how you choose your words…" In other words, because she has a trusting relationship with students and their families, and because she

exercises caution when teaching sensitive topics, Megan can avoid inciting controversy over climate change.

One way teachers exercise caution is by focusing on data and evidence. After noting that climate change is "definitely controversial in our community," Carly explained:

> And how I sort of approach it with the kids is—you know, some of them were arguing with me, or they wanted to argue with me, even though I wasn't presenting an argument—I approached it looking at properties of elements and compounds, and what is the property of CO_2; and then looking at the change in CO_2 levels, and that there must be some correlation.

By making the lesson very data-driven, Carly avoids turning it into "an argument," and thereby minimizes the potential for conflict and controversy. Hailey, too, indicates that if she were to teach climate change in the future, the way she would "frame it is looking at historical data, evaluating—like, look at the model for how the climate is changing… I like that perspective on it, because there's so much, there is so much controversy around it that it makes it very factual, and it makes it very matter-of-fact…" It should be noted that focusing on the data isn't a *bad* pedagogical practice, especially in the science classroom. However it is a tendency that, according to teachers' own reports, is motivated by a desire to diffuse conflict.

One teacher I spoke with at the Oregon Science Teachers' Conference works in a particularly conservative town in southern Oregon and she, like Andrea and Hailey, had thus far avoided the topic of climate change altogether, saying that bringing up the subject would be "like standing in front of a room and saying, 'Here, throw arrows at me!'" She further explained that she hopes to teach climate change in the future, but that she, like Megan, would mitigate conflict by being careful with her words and focusing on

the scientific evidence. She would refrain from actually using the phrase "climate change" until her students have engaged with the data. Then afterwards when, in her words, students "understand it," she would reveal that they've been learning about climate change all along.

Another way to avoid controversy is by sending home a note to parents; both Dan and Kathy employed this tactic before showing the film *An Inconvenient Truth.* According to Dan, "out of 100 kids, there's usually maybe two or three parents that say, 'No way, I don't want my kid to watch that'…It's never been really confrontational. It's always been pretty cordial, and they state their opinion and I state mine, and it's just, 'Yeah, you have a right to that,' and that's fine." He allowed those two or three students to skip the film. Kathy, who also sent home a note about *An Inconvenient Truth*, likewise allowed several students to be excused from the activity. When I asked her why she took this precaution, Kathy explained, "I think it was something that we talked to the principal about… it's kind of like evolution I suppose, in some respects… I don't know why global warming was such a big deal, though! Because, I guess, maybe it was the way he [Al Gore] was pushing it, sort of. I don't know?" It should be noted that Kathy hasn't shown the film in several years (in part due to switching from 6th to 8th grade), and she asserts that if she were to show it today, she probably wouldn't bother to get parental permission. Still, for both Kathy and Dan, the mere *potential* for conflict affected their treatment of climate change, at least in the past. After all, neither teacher sent letters home to parents before showing films about other topics, like plate tectonics or the salmon cycle.

Conflict-Avoidance in the Face of Climate Skepticism

Teachers also minimized conflict in the way they reacted to climate skepticism in the classroom. Another question I asked nearly every teacher was how they responded to students who expressed inaccurate ideas about climate change. Teachers consistently reported that, rather than directly telling the student, "You're wrong," they would subtly correct the misconception while simultaneously validating the student's perspective in a way that mitigated potential controversy. As Hailey explained, the delicate approach she takes in correcting students around "sensitive" issues differs from the more direct approach she applies in other contexts:

> In the context of things that aren't sensitive, if it's something that's a very easy fix, I tell them that directly. I would say, 'Oh I think you have that—what you're saying is not quite correct. What's actually the correct idea or answer would be *this*.'… And for something that's more sensitive… I would say, 'Well, what do you guys think?' Discussion first before I give them what I think or what scientists believe is true" (Hailey).

Though Andrea never discussed climate change specifically in her classroom, she explained that if she *were* to teach the subject, she would ["do what I always do"] take the same approach she takes with other sensitive topics; if a student presented a skeptical view, "I wouldn't push it at all. But I would just [say], you know, 'Your opinions matter, and they're valid, but I don't see any science backing that up.'" Andrea gently identifies a misconception ("I don't see any science backing that up") while being careful not to discredit the student's way of thinking ("Your opinions matter, and they're valid.")

Dan, similarly, doesn't "push it." He explained, "kids will come back and be like, 'My parents said that this—that you're feeding us a bunch of crap,' basically. And you know, we just kind of go through, 'Hey there's scientific evidence, and then there's your personal beliefs, and I'm not gonna—I'm just giving you the information and you have to

decide as an individual what is right." Even though Andrea and Dan agree with the scientific consensus about climate change (and have also affirmed the importance of getting students to understand science and care about environmental issues), both refrain from explicitly correcting students who hold contrarian views. One reason for this, I would argue, is that both teachers are reluctant to create conflict with the student or the student's parents—particularly if they feel that confronting the student is unlikely to change his views anyway.

Several other teachers reported using the same basic tactic in response to skeptical perspectives on climate change: 1) suggest that the student's perspective was scientifically inaccurate, 2) validate the student's right to hold such views. In this way, teachers avoid conflict, both with students and with parents, who may be responsible for the student's perspective in the first place.

- "Yeah, I mean, I make sure that they know I value their opinion, but that opinions change, and I might give them an example of what I used to think and that, that's why we learn and why we get an education… and so [I say], 'You're entitled to your opinion, but make sure that you're open to new things'" (Megan).
- "Always coming back to 'I'm not asking you to change your values system' and honoring where [students] are coming from" (Olivia).
- "And I'm like, 'Well, if that's how your parents feel, that's how you feel; you are entitled to your own opinions. But please don't sway those others that I'm trying to inform.' That's sort of how I've handled it" (Elizabeth).

In addition to forestalling conflict between herself and her students, Elizabeth attempts to discourage student-to-student conflict as well. She described how, when discussing topics like climate change, students will "get into heated debates, and I'm like 'Woah woah woah, woah, woah!'" Elizabeth explained that in these moments, she steps in to say, "Well now, both of you are entitled, like, don't get pissed at each other. You're both entitled to your own opinions. Here's the information.'" Again, rather than taking sides or allowing the debate to continue—either of which could aggravate the conflict—Elizabeth quickly puts out the fire by validating both students' perspectives and then presenting herself as a neutral source of data: "Here's the information."

It may seem inconsistent that teachers are reluctant to challenge students' beliefs, when they are so willing to make students feel bad in other ways. Nicole, for example, has no fear about making students feel "like the world is going to end" or that they should "take some responsibility in it all;" but at the same time, she feels she must "tread very lightly on opinions in my classroom." This paradox likely has to do with teachers' beliefs about the way students respond to negative emotions, versus the way students respond to having their opinions questioned. The former, as teachers explain, gets students' attention and keeps them engaged. The latter, where students perceive an attack to their beliefs or values, is more likely to produce conflict; this is particularly true when students' ideas about climate change are being reinforced at home. It seems that teachers are comfortable causing students to experience inner, emotional conflict, but wish to avoid instigating outward conflict, whether between student and teacher, between student and student, or between teacher and parent. And, given how adept teachers are at avoiding this kind of conflict, it's almost no wonder that instances of outright controversy are rare.

To summarize this section, teachers work hard to avoid conflict over the subject of climate change; however, the strategies they use to mitigate controversy have consequences, and may in fact reinforce some of the major challenges teachers have with climate education. In terms of making climate change "fit," teachers' desire to avoid conflict may justify (consciously or unconsciously) their decision to prioritize other topics over climate change. For first-time teachers, like Hailey and Andrea, this fear of conflict may be particularly pronounced, leading them to avoid the subject altogether.

What's more, in their attempts to avoid conflict, teachers may intentionally or unintentionally reinforce the notion that climate change has "two sides." If a student presents an inaccurate view related to a non-controversial topic, like the periodic table, the teacher is likely to correct the student directly, whereas when a student presents an inaccurate view related to climate change, the teacher is likely to correct the student indirectly (if at all), while simultaneously validating the student's beliefs and values. In this way, teachers may be unintentionally giving students the impression that scientifically inaccurate ideas (i.e. the idea that climate change is a hoax) do, in fact, have some scientific validity—or, at least, that they can coexist with a correct understanding of the science. In this way, social controversy may also help explain the second and third trends related to climate change in the classroom: By refusing to engage in conflict in order to rebut students' skeptical views, teachers may be reinforcing the "both sides" narrative *and* allowing students' doubts and misconceptions to persist despite instruction.

In this chapter I have outlined three significant emotional pressures teachers may face when considering whether and how to teach climate change. Each of these pressures—feeling negative emotions, managing students' emotions, and avoiding

conflict—may play a role in explaining why teachers consistently experience trouble with the subject of climate change. Of course, these pressures are not separate from the direct barriers I outlined in the previous chapter, but rather intertwined with them. Similarly, these pressures are intertwined with a third set of factors I will address in the next chapter: cultural narratives of science teaching.

CHAPTER V

THE CULTURE OF SCIENCE TEACHING: PEDAGOGICAL BELIEFS AND BEST PRACTICES

In Chapter III I described direct pressures that could affect teachers' treatment of climate change in the classroom. In Chapter IV, I moved from the structural to the psychological, addressing how, in addition to the direct limitations of outdated textbooks and restrictive school schedules, teachers and students face emotional pressures that may pose challenges to climate change instruction. In this chapter, I go one step further, moving from the realm of emotions, where the focus is on the individual and her immediate community, to the realm of culture, where the focus is on broader patterns of belief and behavior that characterize and bind a particular community. Here, I will address how the culture of science teaching—a culture shared by formal and informal science educators, along with educational policymakers and researchers—informs how members think about science, about their students, and about pedagogy. These culturally held beliefs, in turn, inform certain best practices in science teaching.

I will address two best practices in particular: first, the practice of "hands-on," "student-centered" pedagogy and, second, the practice of scientific inquiry-based pedagogy. As I will show, these best practices, while productive for teaching many scientific concepts, may not easily translate to the subject of climate change. For example, teachers may struggle to make climate change "hands-on," and therefore prioritize topics like stream ecology or etymology, which better lend themselves to this pedagogical best practice. Similarly, the pedagogical norm of scientific inquiry may

justify, for some teachers, the practice of presenting "both sides" and letting students come to their own conclusions. As I will argue, teachers needn't abandon these culturally approved practices in order to teach climate change in a comprehensive and scientifically accurate way. Rather, teachers may need to think creatively in order to adapt these practices to the unique pedagogical challenges of climate science. Additional training or resources may aid in this process.

Hands-on, Student-centered Pedagogy

According to Megan, the key to good science teaching is simple: "Give them evidence and good hands-on activities and make it about them." The kind of teaching Megan described, what I'm calling "hands-on," "student-centered" pedagogy, differs from what Dan calls "stand-and-deliver" kinds of teaching. Within this paradigm, students should learn content not by reading a textbook or listening to a lecture, but by engaging in hands-on activities—building, testing, and manipulating things with their own hands and observing things with their own eyes. What's more, students need to be able to connect this hands-on learning to their own lives; in Lauren's words, it needs to be "relevant."

In this section, I will first identify *why* teachers prefer this pedagogical approach, then illustrate the ways they apply it to various topics. Finally, I will explain how the pedagogical norm of "hands-on," "student-centered" teaching might impact teachers' treatment of climate change.

Middle Schoolers Are Concrete-Thinkers and Self-Servers

Across the board, teachers asserted that middle school students are concrete, not abstract learners; as such, they learn best through first-hand, hands-on experiences. According to Paul, some students can "sit and get," but the majority of middle school students "are more like, '…if I can actually *do* something, I'm going to be a lot better at it.'" For this reason, Paul prioritizes activities that get students learning through direct observation and experience; "it's all hands-on, getting kids to discover relationships." Megan agreed that while high schoolers, and perhaps advanced eighth-graders, can engage in more conceptual learning, "sixth and seventh graders aren't quite ready to do that yet. [Laughing] They're ready for the hands-on stuff!" Similarly, Dan, who described his students as "concrete learners," explained that "the best way" for them to learn "is just hands-on in the field."

In addition to being concrete thinkers in need of hands-on learning, middle school students are, according to teachers' reports, quite self-centered. One seventh- and eighth-grade teacher at the State Science Teachers Conference explained that it's difficult to get her students to understand world-wide issues like climate change because "their world is very tiny." According to Lauren, students of this age "can't think outside of themselves." In describing middle school students this way, teachers were more matter-of-fact than disparaging. Explained Kathy, in "middle school it's all about *them*. [Laughing]. You know. They can't see the big picture quite yet." Similarly, Megan asserted, "Kids are self-centered. I mean, we all were at that age." Olivia was a little softer in her assessment of her students, but conveyed the same message: "I think sometimes they're—I wouldn't say *self-centered*, but they don't have that global view."

Teachers emphasized local, and student-relevant topics as a way of helping self-oriented adolescents engage with scientific content. At another conference session I attended, an educator from a local extension agency led a workshop on teaching renewable energy through engineering. Like other participants in this study, this educator affirmed that "Reading out of a textbook or doing a worksheet or taking a test—that's not how kids learn… it has to be experiential." She added, "We also know that if it's *relevant* to their lives, they're more likely to really draw that in… [so] we make it as place-based as possible." For example, rather than asking students a question about renewable energy in general, the teacher should ask, "Where does *Oregon* get most of its energy?" Megan expressed this same idea, affirming, "You have to be able to make it about them, or else there's really no point for them to learn it."

When it comes to teaching environmental issues, in particular, teachers emphasized the importance of making learning local to make it relevant, and thus engaging for students. I asked Faith, "Do you feel like it's easier—or maybe even more important—to teach global issues or local issues?" Faith replied, "Absolutely local. These are middle school kids; they know and care about what's in their backyards." Explained Dan:

> I try to do a lot of the local work, just because that's what gets kids really engaged. So at the middle school level… if I can engage them and get them interested, that kind of sets the stage for thinking more globally and being introduced to more complicated problems as they go through high school.

Utilizing Hands-on, Student-centered Pedagogy

Teachers' repeated assertion that "Learning should be hands-on and student-centered" is an affirmation of best practices in science teaching. Thus, when I asked

teachers to describe their "best" lessons, the activities they were most proud of, or the areas of science where they "felt supported," they often described teaching in accordance with this pedagogical norm. That is, teachers described lessons and activities that were hands-on, tangible, and locally relevant. All the teachers I interviewed affirmed their preference for teaching in this manner; so, rather than addressing all fifteen teachers, I will describe two activities that exemplify this "best practice" of teaching in a hands-on, student-centered way.

In Brenda's class, students begin the year by studying a local creek, thanks to a grant from the local water utility funding watershed education. Explained Brenda, "I teach water quality issues in the classroom, and then water quality testing. And then we go out to the creek," where students get their hands wet assessing pH, nitrates, macro-invertebrates, and water temperature. As Brenda explained, "I truly believe kids need old-fashioned experiences, [such as] measuring temperature." By letting students learn in a first-hand, hands-on way, Brenda ensures that even the most concrete learners are engaged. What's more, by focusing on the "city water cycle and the effects of riparian management—or what happens in our local creeks," Brenda caters to her students' "tiny worlds" and makes learning relevant to them. "It's a lot of fun," Brenda affirmed, "you know, the kids really get into it." In fact, watershed science was a popular topic among teachers I interviewed; Dan, Paul, Isaac, Faith, Lauren, and Kathy all reported using a local creek or river as a venue for teaching students scientific content in a hands-on, locally relevant way.

Another popular topic among teachers was tsunamis. Two teachers, Olivia and Hailey, reported taking advantage of a tsunami science program sponsored by a local

university. Recalled Hailey, “So they sent us kits of balsa wood and tape and ping pong balls, and the students built structures on these little boards. And then we took them to [the university] and they latch them in and then crash different size waves over them.” Students had the hands-on experience of building structures and then got to personally observe the effects of a tsunami on coastal buildings. “And it was great,” said Hailey. “They were really engaged.” Olivia, whose students participated in the same program, noted that students could connect this scientific learning to their real lives, asking, “If it’s not relevant, why do we care about building these structures? Well, it's the reality of one happening on the Oregon coast.”

Teachers Struggle to Make Climate Change Hands-on and Student-centered

As science topics, watersheds and tsunamis are, in many ways, comparable to climate change. All three issues are scientifically complex; all three are interdisciplinary (incorporating concepts from physics, earth science, biology, and other disciplines); and, all three issues are consequential for human society. Tsunamis, like climate change, are also somewhat frightening. It’s interesting, then, that teachers count watershed science and tsunamis—and *not* climate change—among their favorite topics. I argue that one reason teachers prefer (and therefore “fit in”) lessons about tsunamis and watersheds is because these topics more easily accommodate the cultural prescription to make learning “hands-on” and “student-centered.” Climate change on the other hand is, according to teachers’ reports, difficult to teach in a way that is both tangible and seemingly relevant to students.

Participating teachers acknowledged that, compared to other topics, climate science is particularly "conceptual" and "intangible," a fact they find pedagogically challenging. Said Dan, "It's very abstract and so, at the middle school level, it can certainly be introduced, but it's not really until high school that they can really get their heads around it a little better." In Oregon, where, as Gabby notes, "we're in sort of a temperate zone," climate change is particularly "hard to see," and therefore difficult for self-centered, concrete learners to understand or appreciate. Elizabeth agreed that "climate change is really hard, because they can't go practice it or see it… how do you do a lab on something that's taken hundreds of years?… There's nothing *tangible*. You can't look at it under a microscope." Elizabeth reports that, as a result, "I struggle in that unit finding activities for them, other than just reading and movies."

Several other teachers confirmed that, for them, making climate change hands-on and relevant for students is difficult. Faith reported that when it comes to "teaching climate change, there are zero, like zero hands-on activities." Even evolution—another socially controversial and conceptually difficult topic—is more amenable to hands-on, student-centered teaching than climate change. According to Megan:

> Evolution for me, teaching that concept is easy because, just, telling kids that everything changes and there's constant change in the world—and look, we can see it, it's right here! We can even measure it in our own classroom. Let's get some fruit flies or whatever and play with them, you know?... But then, when you try to reach to something like climate change, it makes it a lot harder. [Students] can't see that immediate impact. They can't see like right now, why it would be important to know about—does that make sense?

Teachers' inability to find good "activities" related to climate change is not a *structural* deficit, per se; rather it has to do with how climate change, as a global, intangible phenomenon, doesn't easily accommodate the culturally accepted best practice

of teaching tangible, observable, and locally relevant content. Lauren alluded to this fact, explaining, "Because it's not like you can go outside and be like, 'Look! It's warm today, therefore, climate change.' Which is too bad." In fact, as several teachers noted, an experiential approach to learning about climate would actually *confuse* students, since day-to-day weather phenomena aren't actually evidence of climate change. In other words, you can teach students about water quality by having them measure stream temperature, but you can't teach climate change by having them measure local air temperature.

Teachers' beliefs about middle school students and the best way to teach them may explain, in part, why so many teachers lead extended, comprehensive units on watersheds, but address climate change only briefly. In an effort to satisfy the cultural prescription to make learning hands-on and student-centered, teachers may naturally prioritize certain topics—like watersheds, tsunamis, or even evolution—that more easily lend themselves to this kind of instruction. Therefore, it's not just that climate change doesn't "fit" in a crammed curriculum or a busy school day; it's that climate change doesn't "fit" into culturally approved best practices in science teaching. In order to teach climate change, then, teachers must either abandon the cultural norm of hands-on, student-centered instruction (which could have consequences both for student learning and for the teacher's own sense of cultural identity), or find a creative way to make climate change work within the norm.

It should be noted that a few teachers *did* come up with creative ways to make climate change hands-on and relevant; these were also some of the teachers who seemed most confident about teaching the subject. For example, the activity that Olivia developed

as part of the teacher professional development program in climate change had students learn about climate change by manipulating satellite imagery. Olivia acknowledges that climate change is "hard to see. [But] that's why we start really small." Students start by looking at their hometown—in fact, many began by immediately finding their own houses—and then zooming out to the United States. Finally, they "went up to the Bering Glacier and talked about glacial movement and things like that." So slowly, according to Olivia, they "broaden their scope of understanding."

Isaac has been a long-time advocate of field-based learning; over the years, his students have planted trees, examined macro-invertebrates, monitored fish weirs, and collected marine debris. Recently, however, he's begun to brainstorm ways this experiential learning approach could be applied to climate science. Isaac explained that he's "going to learn about a way of monitoring wetlands for climate change." He also described talking with other teachers about "trying to monitor acidification with oyster shells and freshwater mussels." While Isaac hasn't implemented these activities yet, they represent potential solutions to the conundrum of making climate change "fit" within the model of hands-on, student-centered pedagogy.

Scientific Inquiry-based Pedagogy

By engaging students in hands-on learning, teachers hope to give students opportunities to *do* what scientists *do*—i.e. manipulate, measure, and observe the physical world. In this section, I describe a second best practice of science teaching: inquiry-based pedagogy. This pedagogical approach involves helping students *think* the way scientists *think.* Inquiry-based pedagogy recognizes that scientists have a certain way

of forming knowledge about the world, distinct from belief or superstition and that students, in turn, should practice this same epistemological process. Often this means letting individual learners come to their own conclusions, rather than feeding them scientific conclusions via textbooks, movies, or other non-interactive means.

Teachers consistently celebrated inquiry-based pedagogy as a best practice in science teaching. However, as I will show, applying this teaching method to climate change sometimes proved problematic.

Teachers' Beliefs about the Nature of Science

At the heart of science is *inquiry*. The National Science Education Standards (a guide to science education that preceded and influenced the NGSS) define scientific inquiry in the following way:

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work… Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results" (National Research Council, 1996, p. 23).

I observed that middle school science teachers spend a surprising amount of time thinking and talking about the nature of science. My research participants frequently referred back to this idea of "inquiry" when describing and justifying their own views on science and science teaching.

At the State Science Teachers Conference, I attended a session devoted to discussing the nature of science. At this session, participants were instructed to break into

small groups and discuss the difference between four different ways of knowing: math, art, religion, and science. For each of these pursuits, participants were asked to consider, "What's the goal?" and "What counts as evidence?" These participants (who taught a variety of science subjects, in a variety of grades and contexts—not just middle school) agreed that it's important to distinguish science from other epistemologies. One teacher described science as "inquiry with a logical mindset." Another added that the goal of science is "to understand phenomena using direct observation as evidence." Participants were also strict about what counted as "evidence" in the context of scientific inquiry, using adjectives like objective, empirical, testable, observable, reproducible, and quantifiable. In this way, science as a source of knowledge differed from art and religion, where one could admit evidence based on "revelation," "tradition," "ritual," and anecdotal experience.

In this workshop, participants were specifically asked to describe the nature of science and contrast it with other ways of knowing. Notably, in my interviews, I found that teachers continued to make this epistemological distinction, even when they were not explicitly prompted to do so. They, too, seemed concerned about defining the parameters of scientific inquiry. For example, Hailey explained that when teaching touchy subjects, like age of the earth, she tells students, "This is information that scientists have; they have evidence to support this information. It is a *theory*, which in science means that it is proven to be true. And I'm not trying to change your belief system, but this is science…." Here Hailey describes the basic process of scientific inquiry, by which scientists use evidence to construct time-tested theories about how the world works; she also contrasts this process with other epistemologies, like "your belief system."

In addition to distinguishing for themselves between "real science" and non-scientific ways of knowing, teachers take responsibility for helping their students make this same distinction. Brenda actually teaches a whole unit she calls "Science vs. Superstition." In this unit, she assigns a historical novel about the development of modern medicine in Colonial America. In the novel, a young protagonist loses his family to tuberculosis, then apprentices with a progressive physician who teaches him to shed his superstitious notions about disease and death, including "the belief is that someone who died… comes back to life to haunt the living." As Brenda explains it:

> The doctor wants him to believe that there's a scientific way of doing things, and you have to have proof. And without that proof, you can't make that next—so anyways, it's a great book to kind of teach the scientific process, and the whole idea of where science came from, how it evolved to where it is today… kind of the idea of where we are—where we are based on a set of rules that we follow and prove or disprove.

For Brenda, it's important that students learn not only scientific *content*, but scientific *process* as well; they should understand that there's a "scientific way of doing things," and that "proof" and "rules" govern this inquiry process.

Utilizing Scientific Inquiry-based Pedagogy

If inquiry is the process by which scientists use objective evidence to form conclusions about how the world works, then inquiry-based pedagogy means teaching in a way that allows students to practice this same epistemological process. Though there is some debate in the science education literature about what, exactly, constitutes inquiry-based pedagogy (see, for example Wilson, et al, 2009), there is a general agreement that, in this style of learning, students discover knowledge via their own critical thinking, rather than having knowledge delivered to them through didactic instruction (NSTA,

2004). In other words, rather than simply receiving a scientific fact, like "force equals mass times acceleration," students should learn this truth by thinking like scientists; they might experiment with toy cars or hammers or wrecking balls, for example, and conclude that a more massive object indeed exerts more force than a less massive object. While some guidance from the teacher is necessary, ideally students would do most of this intellectual legwork on their own, with the teacher acting in a facilitative, rather than didactic, role.

It should be noted that inquiry-based pedagogy and hands-on pedagogy are not mutually exclusive; in fact, they often go together. At the "Teaching Renewable Energy" session I attended at the State Science Teachers Conference, the same educator who emphasized that learning should be "hands-on" and "relevant" also emphasized, "We don't give away the answers; we facilitate students' thinking." Through this approach, teachers should convey to students, "You're a *scientist*!" Similarly, the teachers I interviewed consistently reported that, in their classrooms, they tried to get students to engage in this kind of process-oriented, inquiry-based learning. The following examples demonstrate how two different teachers employed this pedagogical strategy. According to Paul:

> Each of the last two years I've had kids doing original research in the classroom. We were looking at rain gardens and stormwater filtration two years ago. Those kids built rain gardens and did research on it. For example, one group asked, "Do they work? Or do they not?" And so they used aquarium gravel… they ran stormwater through it, and did [the water] change? Then they did one with dirt—did it change? Then they wrote these actual research papers on it and there were a ton of other things they had to learn.

Rather than simply telling students, “Stormwater filtration systems use gravel to clean the water,” Paul set up the lesson so that students would come to this conclusion on their own, by observing and analyzing evidence. As Paul explains, “instead of just saying ‘here’s how it is,’ we’re trying to walk them through how we figured that out.”

Nicole, similarly, describes her insect unit, in which students use scientific inquiry to understand how habitat diversity affects species diversity:

> I basically try to get them to develop their own investigation on studying bugs using the schoolyard as a research plot… And so, we form the question, and we come up with a hypothesis and basically the project is, we take different colored bowls of water and place them in different areas of this courtyard—this controlled, courtyard environment. And every day at the same time we collect the insects, we remove the traps, we bring them inside, we have a dichotomous key and we key them out, then we record the data... And we go through the whole scientific inquiry process… And then after we’ve collected the data, we graph it. And we conclude and figure out which bugs prefer which colors. And then, how can we modify our schoolyard to increase [insect] biodiversity.

Again, Nicole could have simply explained to her students that different kinds of insects prefer different colored plants, and that diversifying their schoolyard vegetation could, in turn, increase insect biodiversity. However, Nicole, like many of the teachers I interviewed, strongly believes that students learn better when they are able to come to this conclusion on their own.

It’s worth noting that in all these cases, teachers continue to apply principles of hands-on, locally-relevant learning alongside inquiry-based pedagogy. Indeed, these two pedagogical strategies often go together.

Inquiry-based Pedagogy in Education Literature

Based on teachers' descriptions of using inquiry-based teaching, I can see why teachers prefer this pedagogical approach to a more didactic one; it's fun, it's engaging, and, when done well, it can get students to learn content in a meaningful and memorable way. My research participants aren't alone in preferring this teaching strategy; indeed, their stated preferences are reflective of a larger trend in the culture of science teaching in the US.

Inquiry-based education is frequently advocated in state standards and science education literature alike. The Next Generation Science Standards, in particular, emphasize that, in addition to understanding scientific content, students should be proficient in "Asking questions," "Analyzing and interpreting data," and "Engaging in argument from evidence" (Appendix F). Indeed, the NGSS standard relating to climate change stresses scientific process as much as content knowledge. According to this standard, students shouldn't simply *know* certain facts about the atmosphere; they should be able to "*Ask questions* to *clarify evidence* of the factors that have caused the rise in global temperatures over the past century" (MS-ESS3-5, emphasis mine). Again, students are challenged to use scientific inquiry as a way of learning for themselves what other scientists—through that same process of inquiry—have already learned.

Inquiry-based education has been a topic of interest in the science education literature for over a decade. Several studies have confirmed that inquiry-based teaching methods can result in greater and more persistent knowledge gain in students (for example, Wilson et al, 2009; Hmelo-Silver et al, 2007). At the same time, other studies have suggested that inquiry-based teaching can be confusing and frustrating for students,

especially if the teacher provides too little guidance (Kirshner et al, 2006). In the context of climate change, this debate is significant because it remains unclear whether inquiry-based learning could help students overcome persistent gaps and misconceptions in their knowledge of climate change, or whether inquiry-based learning might actually reinforce those gaps and misconceptions. To my knowledge, no studies have tested the link between inquiry-based instruction and student knowledge of climate change specifically.

Teaching Both Sides to Promote Inquiry

My own research supports the idea that, while inquiry-based teaching could *theoretically* lead students to better appreciate the scientific basis for anthropogenic climate change, an inquiry-based approach can also be problematic in the context of climate change.

For one, an inquiry-based approach may encourage teachers to present "both sides" of climate change. Just as teachers have a hard time making climate change "hands-on," and "relevant," so too, they may struggle to teach climate change in a way lets students practice scientific inquiry. While students can perform actual experiments to understand insect biodiversity in the schoolyard, the scale and complexity of climate science mean that students can't easily replicate the kinds of research that real-life climate scientists do. Teachers may respond to this hurdle by creating an artificial experiment: looking at evidence from "both sides." By putting climate science "on trial" (as Paul, Lauren, and Olivia do), teachers are engaging students in a kind of inquiry-based exercise in which students start with a question (Is climate change caused by

humans, or not?), analyze evidence from "both sides," and ultimately use this evidence to develop "scientific" conclusions.

An article in *Science Education* described a study in which researchers actually *encouraged* teachers to take this "both sides" approach to climate change, as a way of helping students practice scientific inquiry (Pimentel and McNeill, 2013). Participating teachers were first coached in "dialogic instruction," an inquiry-based technique that emphasizes student-led discussion as a route to knowledge gain. Then, teachers showed students "two video clips depicting different perspectives" on climate change. Following that, the teacher would ask students to use evidence from the video to write an argument about whether climate change was occurring, then facilitate a student-led discussion on the subject. According to the principles of dialogic instruction, the teachers were trained to merely facilitate conversation—to prompt students to use evidence and to think critically—but to refrain from asserting the "correct" view regarding climate change.

The fact that this article was published in the oft-cited academic journal, *Science Education,* suggests to me that the trend I saw in my interviews—where teachers address "both sides" of climate change—is not anomalous, but consistent with a larger trend in the culture of science teaching, where the teacher's primary responsibility is to encourage inquiry-based thinking, rather than asserting conclusions.

In this trend lies a seeming contradiction: If teachers favor the kind of evidence-based thinking characteristic of science inquiry, and if most scientists agree that climate change is real and caused by humans (a fact that all but one teacher affirmed), why would teachers even entertain arguments from the "other side?" One possible reason is the way that skeptical arguments are framed. Because arguments from the "other side" are so

frequently couched in the language of science, based on scientific evidence (however misconstrued), and presented as products of scientific inquiry (Greenpeace, 2013; Oreskes and Conway, 2010), they may be admissible to the science classroom. A more compelling reason, however, is that by presenting "both sides," teachers feel they are giving students the opportunity to engage in scientific inquiry, an activity that *will* ultimately lead students to the correct conclusion (i.e. the understanding that human activities are causing climate change). What's more, teachers argue that this inquiry-based approach is more powerful than simply asserting the scientific explanation for climate change and saying, *This is how it is, kids.*

The way Faith explained it, "Because they're little kids, a lot of them hold on to the attitude that their parents have. That's why a lot of them say, 'I don't believe in global warming, I don't believe in evolution.'" In these cases, rather than asserting the "correct" view, Faith encourages her students to consider the evidence on both sides and make up their own minds. Addressing a hypothetical middle schooler, Faith explained:

> You're *twelve*! You haven't had enough exposure to the world to really make that decision or not. You're just parroting back what someone else told you! And you know, if I teach you these things are real and they exist, and you should worry about them, you're just parroting back what I told you, you know. And there's no point in that either; that's just as evil. You gotta learn how to be able to look at data sets and make up your own mind.

Faith makes a compelling argument that if students can "make up their own minds," their conclusions are going to be more meaningful than those "parroted" back from a teacher, parent, or other third-party source of information.

If this inquiry-based approach reliably led students to the "right" answer concerning climate change, I would have little to criticize. However, as I have illustrated

and will further explain, students *don't* always arrive at the "right" answer. Students' doubts and misconceptions often persist, and for many possible reasons. Perhaps the student didn't receive enough training in evidentiary thinking, or didn't receive enough evidence to make a sound conclusion. Or, perhaps the student successfully arrived at a scientifically valid conclusion, but then couldn't reconcile that information with his emotional or religious assumptions. Either way, when students assert inaccurate conclusions, a teacher who is committed to inquiry-based pedagogy may feel conflicted. Should she continue to encourage inquiry-based thinking at the expense of correct knowledge? Or should she emphasize correct knowledge at the expense of her students' intellectual autonomy?

Doubts and Misconceptions Persist with Inquiry-based Model

Even when students are coached in inquiry-based skills like identifying relevant evidence and assessing its validity, they may still arrive at the "wrong" conclusion; for example, they may insist, as Lauren's student did, that when it comes to climate change: "We are not the problem." Why the disconnect? Obviously, students could form inaccurate conclusions about *any* subject. However, at least two factors heighten the risk that students would misinterpret evidence about climate change, in particular. First, the scientific evidence for climate change is vast. Students can't weigh it all at once. As a result, there's no way for seventh-graders to analyze all this evidence and independently conclude that climate change is happening and caused by humans. (Indeed, individual scientists can't even weigh all this evidence at once; the Intergovernmental Panel on Climate Change was created specifically to address this fact). Secondly, the sorts of

factors that would compete with objective, scientific evidence—i.e. beliefs, emotions, and media messages—are amplified in the context of climate change. While students are unlikely to experience emotional resistance to the scientific evidence for Newton's Laws, students *are* likely to experience emotional resistance to the scientific evidence that human activities are causing Earth's climate to change. For this reason, students' process of objective, scientific inquiry may be derailed, causing them to arrive at conclusions that differ from the scientific consensus. This fact may explain, in part, why students' doubts and misconceptions about climate change persist, even when teachers do their best to show students evidence and encourage students to critically assess that evidence.

Teachers Are Reluctant to Correct Students' Doubts and Misconceptions

Because inquiry-based pedagogy is the cultural norm for teachers, when students *do* arrive at the wrong conclusions (or when doubts or misconceptions persist), teachers were sometimes unsure of how to correct those conclusions.

In Chapter IV, I explained that teachers are reluctant to categorically dismiss students' skeptical claims about climate change, in part due to fear of conflict. I would add that *another* reason teachers refrain from correcting students is because they are firmly attached to the belief that "good" science teachers don't just give students the answers; they let students formulate answers on their own. What's more, consistent with their view of the nature of science, teachers are committed to segregating objective, scientific evidence from other sources of knowledge. Thus, teachers find themselves in a particularly awkward position when, despite their efforts to promote evidence-based thinking, students continue to present views based on religious belief, politics, or

personal values. In these cases, the teacher, due to the cultural norms of her own discipline, is reluctant to say, "You are wrong." Instead, she will often say something like, "Well, that view is unscientific, but since it's your *belief,* you can believe whatever you want." Time and time again, teachers used this refrain, or some variation of it, when describing how they responded to scientifically inaccurate claims in the classroom. Here are just four examples:

- "Hey there's scientific evidence, and then there's your personal beliefs… I'm just giving you the information and you have to decide as an individual what, you know, is right" (Dan).
- "This is the evidence; what your personal beliefs are is your choice. But this is the evidence that shows this is what's happening. Whether you choose to believe it or not is your [choice]" (Elizabeth).
- "That's where you just look at them clear in the eye and say, you know, 'I don't need you to *believe in* it, I need you to *understand* it'" (Faith).
- "I would just [say], 'Your opinions matter, and they're valid, but I don't see any science backing that up. Find your own articles with more science to back it up'" (Andrea).

In all of these passages, the respondent makes a clear distinction between scientific inquiry and belief (or other non-scientific forms knowing, including opinion, religion, etc.). Meanwhile, the teacher carefully validates the student's epistemological process, even as she makes it clear what does and does not count as science. Rather than telling the student "you are wrong," the teacher effectively tells the student, "your belief, while valid, is not supported by scientific evidence.'" And, consistent with the norms of

inquiry-based pedagogy, the teacher doesn't simply tell the student what the "right," answer is, but refers the student back to the scientific process: have an open mind; do research; find evidence. Then come back to me. Ideally, through this iterative process, the student would eventually come to the correct conclusion. But, since the process is student-directed, the student's misconception may also persist. And, since the teacher's role is not to arbitrate facts, but rather to facilitate a certain thinking process, the student's contra-factual conception receives no direct challenge.

Successfully Adapting Inquiry-Based Pedagogy to Climate Change

Just as there are ways to adapt hands-on, student-centered pedagogy to climate change, so too, there are ways of applying inquiry-based pedagogy to climate change so as to avoid the pitfalls described above.

For example, teachers might relax the prescription to "let students decide for themselves" in cases, like climate change, where the evidence is vast and socially contested. As Gabby noted, when it comes to climate change, "the students just get kind of confused. Because they've heard both sides, and they don't really know what to believe." Even though her students are confused, Gabby, like other teachers I interviewed, worried about how to address that confusion without veering into didacticism. "They [the students] usually believe whatever I say," she explained; "It's almost *too* much power sometimes…" I would argue, however, that climate change is one subject where teachers like Gabby might *embrace* that power, using their authority to assert scientifically valid conclusions, rather than always encouraging students to decide for themselves. After all, students often look to their teachers for confirmation of facts

and theories. Said Nicole, “You know, they want to know the *truth*. They want to know—they hear that there's this controversy that global warming isn't happening. And they want to know, from *me*, is this true?”

One way that teachers might teach climate change *without* compromising the tenants of inquiry-based pedagogy, is to shift students’ attention from non-questions like, “Is human-caused climate change even occurring?” to questions that are actually debatable, like, “How will sea level rise affect the Oregon coast?” or “What are the pros and cons of various renewable energy sources?” Here, students can still practice inquiry-based skills like finding evidence, assessing evidence, forming conclusions, and defending those conclusions. Plus, with many of these questions, students’ opinions, emotions, and values would be welcome additions to the conversation, rather than a distraction. Some teachers are already applying this approach in certain ways; for example, Brenda reported teaching a lesson on forms of transportation that challenged students to weigh various pieces of evidence about cars, buses, and bikes, in order to determine which mode contributed the least to climate change. Circling back to the issue of pedagogical resources, this is one area where additional curricula or training may be useful.

In summary, in this chapter I’ve characterized teachers’ beliefs and practices regarding the “best way” to teach science; I’ve also argued that these beliefs and practices are not enacted in isolation, but are part of a larger culture of science teaching. Within this culture of science teaching, certain pedagogical strategies, including hands-on, student-centered, and inquiry-based learning are normalized and prioritized, sometimes to the detriment of climate change education. Does this mean that teachers should abandon

hands-on, student-centered, and inquiry-based approaches when teaching about climate change? By no means! However, teachers might need to think outside of the box, perhaps modifying these approaches, in order to successfully apply them to the subject of climate change.

CHAPTER VI

CONCLUSION

In this thesis, I have examined various pressures that directly and indirectly affect teacher practice in the context of climate change. While it was encouraging to see that most (14 out of 15) teachers accepted the scientific consensus about climate change, felt concern about it (15 out of 15), and were taking steps to address this issue with their students (13 out of 15), it was also significant to recognize that problematic trends persist. Specifically, the teachers I worked with tend to minimize the topic, suggesting that it doesn't "fit;" they teach in a way that explicitly or implicitly acknowledges "both sides;" and, they observe that students maintain doubts and misconceptions even after instruction.

Unlike other studies, which explain these problematic trends by identifying specific pedagogical challenges, like an absence of resources or the presence of political controversy, I have taken a more broad approach, in order to understand how direct barriers are compounded at both the personal and communal level, through emotions and cultural norms. Structural, emotional, and cultural factors, then, are interwoven; together, they shape the practice of climate change in the classroom.

I return, then, to the question that began this thesis: "What should students know about climate change?" The Next Generation Science Standards assert that, at a minimum, students should understand "the factors that have caused the rise in global temperatures over the past century," including "the major role that human activities play" (MS-ESS3-5). Environmental educators would cite the normative goals of climate

education as well; according to the Oregon Environmental Literacy Plan, in addition to understanding the science students should demonstrate the skill and the willingness to "work individually and collectively toward resolution of environmental concerns and to participate thoughtfully and effectively in decision-making" (p. 23). These are lofty goals indeed, and won't be accomplished overnight. At the same time it's clear, at least from the teachers I spoke with, that significant challenges remain, frustrating teachers' ability to work towards these goals. In other words, there is room for improvement.

What Now? Strategies for Empowering Teachers of Climate Change

In this thesis, I have identified various and complex problems related to climate change in the classroom. What now should be done about these problems? How can advocates of climate education—be they formal or informal educators, policymakers, academic researchers, or community organizers—help teachers engage in this critical task of communicating climate change?

I am not a middle school teacher myself, nor am I a trained expert in science pedagogy. My goal, in writing this thesis, is not to prescribe solutions per se, but to describe the situation at broader level than is usually done in the academic literature on climate change education. That said, I will offer some ideas, based on lessons learned from this study, about how climate education advocates might go about addressing the challenges of climate pedagogy at different levels.

Overcoming Direct Barriers

When it comes to direct barriers, proponents of climate education should avoid accusing teachers of scientific illiteracy (as so many academic articles do), and instead affirm the knowledge that teachers *do* have, help them gain access to resources that already exist, and solicit their input in developing new resources, as necessary. While attending the State Science Teachers Conference, I observed three different sessions focused on climate change pedagogy. Two of these sessions failed, in my mind, to validate teachers' existing knowledge and provide them with resources, while one, as I will illustrate, better accomplished this task.

In the first session, "Climate Change: Facing the Challenge," a representative from a nationwide climate advocacy organization delivered a PowerPoint presentation, Al Gore-style, that covered the basics of climate science, including the causes, the effects, and the steps individuals and communities can take to mitigate the problem. The presenter, "Mark," was a volunteer educator for this particular climate advocacy organization, and had delivered this same presentation to students throughout northwestern Oregon, at no charge to participating schools. A few teachers asked Mark if, rather than having him visit their classrooms, he would be willing to share his PowerPoint, so that they, the teachers, might use it themselves. Mark was apologetic, but firm, explaining that his organization forbid him from distributing resources for others to use; if teachers wanted the information, they would have to schedule a visit from a designated presenter, like himself. In this way, rather than affirming teachers' knowledge and competence as climate educators, and empowering them to continue this work on their own, Mark suggested that the task of climate education is better left to "experts."

A second session, “Teacher Professional Development in Climate Science” described a training program that teachers could enroll in outside of school to learn more about climate change. This program was administered by a local university and would satisfy ongoing education credits that public school teachers are required to meet. Just a few participants attended the session: five other teachers and myself. The leader of this session, too, who I’ll call Ron, perpetuated the assumption that teachers are ignorant of climate science. As he described each of the units in the teacher development program, Ron constantly talked down to the educators in the room. “You know what *CO_2 parts per million* is?” he asked us at one point. Collectively, we nodded and affirmed our familiarity with the concept. Instead of acknowledging our response, however, Ron brushed us off, saying, “I think I might tell you anyway;” he then proceeded to explain a concept we had all just indicated that we understood. Not surprisingly, the few teachers in attendance began to check out; I looked over and saw one teacher doodling in her conference program and another catching up on grading.

The third session, “Collaborative Conversations about Teaching Climate Change,” was the least structured, but also the most meaningful from my perspective as a participant. While this session, too, had a moderator, it was primarily participant-led. In small groups, teachers posed problems that they had experienced regarding climate change in the classroom, and other teachers responded, acknowledging when they had experienced this same problem and offering possible solutions from their own experience. For example, when one teacher expressed frustration with the challenge of making climate change hands-on—“I’m always thinking about, what can I have them *do*?”—several other teachers suggested activities they had used: a solar oven competition,

measuring carbon sequestration in trees, and testing air temperature inside and outside a greenhouse. Teachers also referred their peers to the specific books and curricular manuals where they had found these activities. One middle school science teacher described how he overcame two problems: the problem of disciplinary boundaries and the problem of not enough time, by collaborating with the language arts and social studies teachers at his school, assigning students an interdisciplinary climate change project that spanned three class periods. Because this conference session lasted only an hour, the amount of information and support that teachers were able to get was limited; however, it suggested to me that teachers, when given the opportunity to share their expertise with each other, may actually have the resources they need to overcome some of the persistent challenges in climate change education. Again, additional training and resources may aid teachers, but these supports have be tailored to the actual needs and wants of teachers.

Dealing with Emotional Pressures

As I have argued, it's not enough to simply ensure that teachers have the knowledge and resources necessary to teach climate science; emotional factors also impact how educators address this socially controversial issue. For example, teachers' consistent preoccupation with their own carbon footprints, including what they should or shouldn't be doing to combat climate change in their personal lives, may inspire feelings of guilt or overwhelmedness—feelings that are likely to frustrate, rather than facilitate their own engagement with climate change (not to mention their ability to engage students).

Completing this research cemented my own conviction that empowering people, including teachers, to meaningfully deal with climate change requires a cultural shift away from narratives of personal responsibility—i.e., "climate change is a problem of individual environmental sins, to be mitigated by individual behavioral changes"—and towards narratives that highlight structural problems and collective responsibility. In his seminal essay, "Individualization : Plant a Tree , Buy a Bike , Save the World?" Michael Maniates describes these two narratives and their consequences:

> [Working within the first narrative], environmental groups will work hard to "educate" the citizenry about the need to buy green and consume less and, by accident or design, the pronounced asymmetry of responsibility for and power over environmental problems will remain obscure… The other road, a rocky one, winds towards a future where environmentally concerned citizens come to understand, by virtue of spirited debate and animated conversation, the "consumption problem." They would see that their individual consumption choices are environmentally important, but that their control over these choices is constrained, shaped, and framed by institutions and political forces that can be remade only through collective citizen action, as opposed to individual consumer behavior.

One teacher I interviewed, Carly, is already trying to get her students to think about the difference between individualized and collective responses to environmental problems. For example, she described a simulation activity where students calculated the carbon emissions of different fictional families, compared those emissions to levels required by international treaties, and then discussed how to get high-emitters to comply with emissions reductions. According to Carly:

> …each person got a card about a family, that's who they were. And they calculated their carbon emissions. And some of them didn't meet the treaty and some of them did. And so it split them in half. And I said, "Okay, to those of you who met [the treaty], *these* people didn't meet. What do you think about that? Do you think a law should be [created]—or do you think we should use public policy…? And you over here who *didn't* meet [the treaty], how are you going to justify you not meeting?" And looking at what the personal choice and public policies are.

Thinking about climate change as a structural problem with structural solutions may free both teachers and students from the emotional burden that often accompanies the subject of climate change. Of course, thinking about climate change in this way also politicizes it; the solutions are no longer individual choices, like riding a bike, but social and economic changes, like putting a price on carbon. If some teachers fear that they will face conflict when discussing climate change from the perspective of scientific evidence and individual responsibility, then discussing the socio-political implications of climate change may be even more intimidating. For this reason, advocates of climate education should market, as much as possible, stories of teachers successfully navigating these issues *without* suffering significant interpersonal conflict. For teachers like Andrea, who have never personally experienced controversy, but who avoid climate change because they have "heard horror stories," hearing "success stories" may be particularly empowering.

Working within the Culture of Science Teaching

In the previous chapter, I described how culturally held beliefs about students, about science, and about pedagogy, inform the way that teachers teach. These best practices, while effective for certain subjects, can be problematic when applied to the subject of climate change, if not done carefully. Fortunately, however, teachers needn't reinvent science pedagogy to accommodate climate change education; they may simply need to think creatively, and adapt their practices where necessary.

Earlier, I described a few approaches teachers are already taking to make climate change "hands-on," "student-centered," and "inquiry-based"—including Isaac's proposed

project in wetland monitoring and Olivia's current lesson in analyzing satellite imagery. It's worth noting that Olivia's own confidence as a climate change educator was enhanced by a teacher professional development program she participated in over the summer. This program was sponsored by a local university and employed a "teacher-researcher partnership" model. Along with a handful of other secondary science teachers, Olivia spent three weeks partnering with and learning from scientists whose work directly related to climate change in Oregon. Olivia worked closely with one researcher, who studied satellite data to assess landscape change associated with climate change. Olivia and another teacher collaborated with this researcher to develop the curriculum she would later use in her classroom. As part of this lesson, students manipulated satellite imagery (satisfying their need for hands-on learning), collected evidence that helped them answer questions about landscape change (satisfying their need for inquiry-based thinking), and focused on their hometown and the surrounding area (satisfying their need for relevant, student-centered learning). Olivia described how this teacher professional development experience, and the curriculum she was able to create and implement through it, changed the way she thought about both climate change education and science education in general:

> I think it was interesting, because I know it wasn't just designed by me, it was a team of teachers, and the scientists kind of overlooking to make sure that everything was accurate… And knowing that the time it would have taken me to come up with something like that wouldn't have been possible. But working over the summer… and having science and also having support systems [i.e. from the other teachers in the program], like, "Hey, I just tried to do this; have you guys tried to teach this yet in your class? Did it work? I didn't have tracing paper, I had to use a string." Or you know, whatever the case may be, you're able to make adjustments and let each other know… So it really was a collaborative effort. So thinking about impactfulness, if we could do that more often, I think that would

> have a lot more leverage, kind of a pedagogical shift that needs to take place in science.

Olivia suggests, as I have done earlier, that teachers are fully capable of teaching climate change in a scientifically accurate and engaging way, and that the key may be a balance of support from outside organizations—particularly when that support empowers, rather than patronizes teachers—combined with support from other, fellow teachers. In this way, educators may find both the means and the motivation needed to teach this challenging, but critical subject.

Many Thanks

Thanks to the many educators, both formal and informal, with whom I've had the pleasure of working alongside throughout the years. You have inspired me to think more critically about science, about the environment, and about education.

Thanks to Dr. Kari Norgaard, for advising me in this project and inspiring my interest in climate change communication with her book *Living in Denial.* Thanks, too, to Dr. Kathryn Lynch for further advice and inspiration on the subject of environmental education.

I especially want to thank all the teachers who participated in this study; I couldn't have done it without them. Because this is an academic work, it's hard to talk about individual people, their speech, and their actions without adopting a critical tone. However, this scholarly tone should not be confused with personal reproach. Indeed, I was consistently impressed by the teachers I had the honor of interviewing. I marveled at their creativity, their compassion, and above all, their passion for science teaching. I hope

that if these teachers were to read this thesis, my words—both the critical and congratulatory ones—would resonate with them.

APPENDIX

INTERVIEW SCHEDULE

1. Background for project

2. Tell me a little bit about your experience teaching – how and when you got into teaching, what grades or subjects you've taught, and what grades/subjects you're teaching now.

3. Overview of your year – what units do you teach?

4. What do you think are the most important ES topics for middle school science?

    a. Are all of those topics that you cover?

    b. How do you teach Topic A? (What tools, activities, etc. do you use?)

    c. How do you teach Topic B?

5. One environmental science topic that I'm particularly interested in for this project is CC—I'm curious whether and how teachers incorporate CC into their classroom teaching, especially because the NGSS include this topic a little more explicitly than the past OR state standards did. So if it's okay with you I'd like to spend some time discussing that subject specifically. Is CC a topic that you cover in your classroom?

    If **yes**

    a. Can you walk me through your CC unit or lesson? Starting from the beginning, what are the main points you cover and activities you do?

    b. So, ideally, if your students paid attention and learned what you hoped they would learn from this unit/lesson, what would they ultimately understand about CC?

    c. When teaching CC, do you find that you're more authoritative, like "this is the way it is" or more open-ended, like "here's some information about CC, you make up your own minds."

        i. Is that the same way you would teach for other subjects—like, the water cycle or volcanoes—or do you take a *more* authoritative/open-ended approach when teaching CC?

    d. Has anyone in your school or community tried to encourage or discourage you to teach CC?

e. Do you ever have students present an idea that's more in line w/ climate skepticism than climate science? How do you respond?

If **no**

a. I understand. Maybe you could describe for me how you decide what topics to teach, and why CC wasn't one of those topics.

b. Has anyone in your school or community tried to encourage or discourage you to teach CC?

c. What, ideally, should MS students understand about CC?

6. [Understanding that CC isn't a major topic] can you think of a time when CC or GW came up in class, maybe indirectly or in a discussion, or whatever?

7. Compared to other ES topics like watersheds or biodiversity, what—if anything—is different about teaching CC?

8. Thinking about yourself, not as a teacher, but just as a person--In general, do you think about CC?

a. Do you share those thoughts w/ your students?

9. When you're talking about environmental topics w/ your students (CC or other) do you find you "stick to the science" or incorporate social issues, too?

a. Getting into solutions or responses – Do you ever worry about that being too political?

b. How (if at all) do you keep it from being political?

c. Do you tend to talk more about personal responses to enviro issues (like things that they can do individually like recycling, biking) or more large-scale social responses?

10. [Most teachers want to get students excited] Do you ever worry about making students feel scared or discouraged when talking about env issues, especially environmental problems?

11. Can you think of a time teaching an ES topic when you felt supported and confident?

a. What made you feel confident and/or supported?

12. Can you think of a time teaching an ES topic when you felt *un*supported and/or *un*confident?

    a. What made you feel unconfident and/or unsupported?

13. Anything else I should ask you about?

14. Any questions for me?

15. Are there any other teachers you know that you'd recommend I contact?

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